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VITAMIN C STUDIES ON SURGICAL PATIENTS

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IN 1919, Aschoff and Koch¹ expressed the belief that in scurvy the primary deficiency consisted in a lack of or faulty development of intercellular cement substance. That vitamin C is the specific agent of importance in the formation of intercellular substance was pointed out by Wolbach and Howe,¹³ in 1926. Menkin, Wolbach and Menkin,^{7, 14} later, observed that when vitamin C was given to scorbutic animals, the amount of intercellular substance laid down in the tissues, as judged by microscopic sections, was in direct proportion to the amount of vitamin C given.

More recent work by Lanman and Ingalls⁶ has shown that the presence of scurvy in guinea-pigs interferes with wound healing, and suggested that a vitamin C deficiency might be of importance in clinical surgery. They measured the strength of healing wounds in the abdominal wall and in the stomach of normal and scorbutic guinea-pigs, by inflation of the abdominal cavity or stomach with air under controlled pressure. They found that while the abdominal wounds in normal animals ruptured at an average pressure of 160 Mm. of mercury, the wounds in scorbutic guinea-pigs ruptured at an average pressure of 65 Mm. The stomach wounds broke at 70 Mm. of mercury in the normal animals and at an average of 30 Mm. in the guinea-pigs with scurvy.

The present study was undertaken to determine whether vitamin C depletion, as indicated by its concentration in the blood plasma, could be shown to exist in surgical patients. We have also studied the behavior of vitamin C in the body during the postoperative period to detect any changes which might occur that would clarify the rôle of vitamin C during the active healing process.

Determinations of the vitamin C content of the blood plasma have been made on 13 normal controls and on 188 patients. Most of these determinations were made by titration with indophenol, using the method described by Pijoan and Klemperer.⁹ In some of the later work, the modification of this

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method for use with the photo-electric colorimeter, as described by Mindlen and Butler,⁸ was employed. When the concentration of cevitamic acid was great enough so that all the dye would be reduced, the metaphosphoric acid filtrate was diluted 1:10 with 2.5 per cent metaphosphoric acid and the calculations modified accordingly. At the time that the change in method was made, duplicate determinations were done, using both methods. A close correlation in the determinations was found, the photo-electric colorimeter giving usually slightly lower readings.

Since this work was started, a number of reports have appeared in the literature containing similar determinations on groups of patients suffering from various disease conditions. These are in general agreement with our studies.

From the work of various writers it would appear that an individual who is in a state of "saturation" with respect to vitamin C will show a fasting blood plasma level of about 1.3 mg. per 100 cc. of plasma, or slightly higher. An increase in the vitamin C intake fails to raise this level, and a large proportion of the excess vitamin appears in the urine. This optimum state, while theoretically the ideal one, is certainly attained in normal life by only a small proportion of the general population.

It is agreed that a fasting blood plasma level of under 0.5 mg. per cent is definitely abnormal and that the presence of such a level indicates that the vitamin C in the body tissues has been markedly and perhaps dangerously depleted. In clinical scurvy the plasma vitamin C level is usually 0.1 mg. per cent or lower. The range between 0.5 mg. per 100 cc. and "saturation" must, at the present stage of our knowledge, be considered normal, although it is evident that many individuals falling within this range show varying degrees of partial depletion, below the optimum "saturation" level.

Ingalls and Warren⁵ studied 20 patients with gastric and duodenal ulcers. They found their average blood plasma level to be 0.29 mg. per cent with a range from zero to 1.15 mg. per 100 cc. Wright and his coworkers¹² have reported blood levels on 49 patients with an average of 0.62 mg. per cent and a range from 0.27 mg. to 1.54 mg. per cent. Faulkner and Taylor² studied 165 patients, of whom 95 had infection and 70 were free from infection. The average for the first group was 0.59 mg. per cent with a range from 0.10 mg. to 1.19 mg. per cent, and for the patients without infection, the average was 0.96 mg. per cent, with a range of 0.11 mg. to 2.42 mg. per cent. Rhinehart and his coworkers¹⁰ studied 55 cases of active rheumatoid and "rheumatoid type" of arthritis, 13 patients with gonorrhreal arthritis and 12 cases of hypertrophic arthritis. Their control group was composed of 120 medical students. The controls showed an average blood level of 0.7 mg. per cent, with a range of 0.22 mg. to 1.45 mg. per cent. Of this group, 26.6 per cent were below 0.5 mg. per 100 cc. and 4.2 per cent below 0.3 mg. per cent. Of the 55 patients with true rheumatoid or "rheumatoid type" arthritis, 89 per cent were below 0.5 mg. per cent, and 74.5 per cent under 0.3 mg. per 100 cc. The average for this group was 0.24 mg. per cent. The 13 cases of gonorrhreal arthritis had an average level of 0.22 mg. per cent, with a range of 0.09 mg. to 0.64 mg.

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per cent, while the distribution for the 12 patients with hypertrophic arthritis was above that for the normal controls.

In using the fasting blood plasma level of vitamin C as an index of the degree of saturation or depletion of a given individual, certain facts must be kept in mind. A change in the vitamin C intake, particularly when it is considerably increased, may cause a change in the plasma content, which is out of proportion to the actual degree of saturation of the body as a whole. In other words, we feel that it is possible, by means of large doses of cevิตamic acid, to raise the plasma content to a "saturation" level without obtaining complete tissue saturation. This is shown by the fact that the plasma level falls sharply when the administration of excess cevิตamic acid is stopped.

Our 13 normal controls showed a blood plasma content varying from 0.77 mg. to 1.62 mg. per cent, with an average of 1.24 mg. per cent. In the series of 188 patients on whom fasting determinations were made, the average blood plasma level was 0.43 mg. per 100 cc., with a variation from zero to 1.89 mg. per cent. Of the entire series 126, or 67 per cent, were found to be below 0.5 mg. per 100 cc., and may be considered definitely abnormal with respect to their vitamin C metabolism.

TABLE I
BLOOD PLASMA CEVITAMIC ACID DETERMINATIONS ON 188 CASES

Group	Number of Cases	Average Plasma Cevitamic Acid Mg. per 100 Cc.	Range Mg. per 100 Cc.
Pulmonary tuberculosis.....	7	0.40	0.04-0.85
Ulcerative colitis.....	10	0.54	0.04-0.97
Osteomyelitis.....	10	0.40	0.07-0.83
Carcinoma of stomach.....	18	0.27	0.04-0.61
Carcinoma other than gastric.....	19	0.33	0.02-0.89
Arthritis.....	23	0.37	0.04-1.22
Gastric and duodenal ulcer.....	34	0.34	0.00-1.06
Miscellaneous.....	67	0.57	0.00-1.89
Totals.....	188	0.43	0.00-1.89

To determine whether the type of disease determines the degree of depletion of vitamin C, the patients were divided into several groups. These are shown in Table I. That the average blood level of vitamin C in patients with gastric or duodenal ulcers is low has been pointed out by several writers. The point to be emphasized is that the average level in several of the other groups is of the same order of magnitude as in the group of ulcer patients, so that an equal degree of vitamin C depletion is found, for example, in patients with carcinoma, regardless of its location, and arthritis. The patients with pulmonary tuberculosis and osteomyelitis have only slightly higher average levels. The miscellaneous group shows a somewhat higher average than the others. This is due to the fact that it includes a number of patients with benign conditions whose blood cevิตamic acid levels were relatively normal.

It is obviously impossible to make direct determinations on the tensile strength of the healing wound in normal postoperative patients, and it was

felt that such observations made at autopsy would be affected by so many other variable factors that they would be unsatisfactory.

In an attempt to obtain data which might lead to information on this subject, we have followed the plasma level of cevitamic acid on a number of patients before and after operation. As shown in Chart 1, there is in most cases a definite, although sometimes transient, drop following operation. It seems to be more marked when the initial level is higher, and its degree seems to be somewhat dependent on the extent of the surgical procedure.

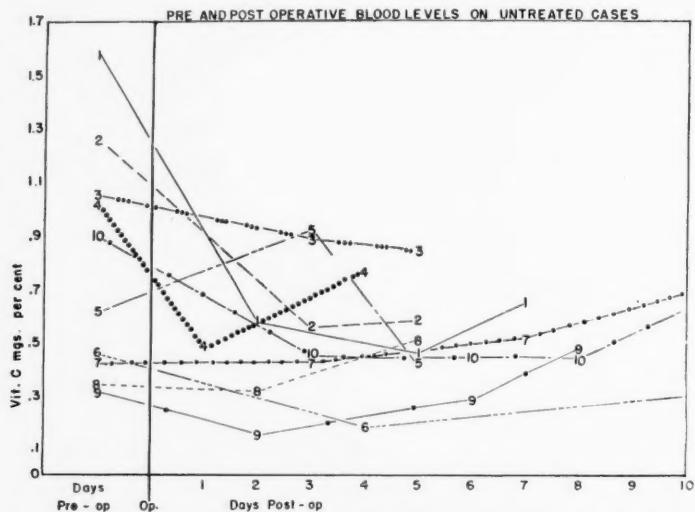


CHART 1.—Blood vitamin C determinations on ten patients before and at various intervals after operation are shown. Most of them show a definite drop in the blood vitamin C level after operation. This seems more marked when the initial level is higher and its degree seems to be somewhat dependent upon the extent of the surgical procedure. The operative procedures on these patients, numbered to correspond with the numbers on the graph are: (1) Lobectomy, (2) Incision and drainage of chronic empyema, (3) Herniorrhaphy, (4) Cholecystectomy, (5) Herniorrhaphy, (6) Abdomino-peritoneal resection of rectum, (7) Gastric resection, (8) Posterior gastro-enterostomy, (9) Gastric resection, (10) Gastric resection.

Eight patients were followed carefully before and after operation with repeated determinations of blood and urine. No supplementary vitamin C was given to these patients. The results of these studies appear in Chart 2. The urinary cevitamic acid was determined by indophenol titration, using the method described by Harris, Ray and Ward.⁴ It must be kept in mind that the accuracy of this method is limited by the presence of other substances in the urine which will reduce the dye. These studies have been included, however, because they seem of interest. They fail to demonstrate any increase in urinary excretion following operation, such as has been described by Geissen-dörfer.³ It is interesting that the two patients with pulmonary tuberculosis excreted an amount of cevitamic acid which is much larger than one would expect, considering their relatively low blood levels.

The consistent, although sometimes slight, fall in the blood cevitamic acid observed after operation aroused our interest, particularly since we could not

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account for a lowering of the blood level on the basis of increased excretion. Since vitamin C is known to be of importance in tissue repair, any evidence of a change in behavior, during a time when active healing is occurring, suggested various interesting possibilities.

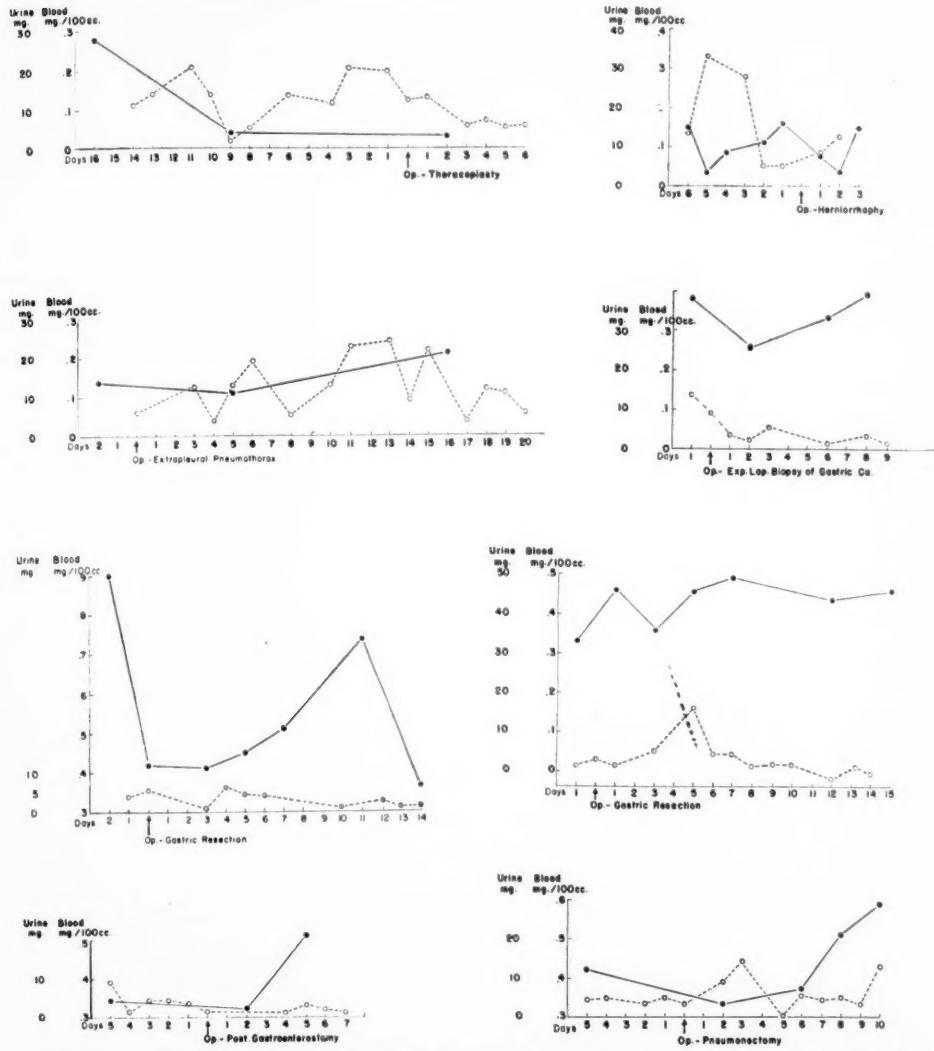


CHART 2.—The blood level and the daily urinary excretion of vitamin C, before and after operation were studied on eight patients and the results are shown above. The solid line represents the blood plasma vitamin C in mg. per 100 cc., and the broken line shows the urinary excretion of cevitamic acid in mg. per 24 hours. No increase in excretion following operation was noted. The two patients who had thoracic operations, both of whom were suffering from pulmonary tuberculosis, seem to excrete an amount of vitamin C which is much larger than one would expect, considering their relatively low blood levels.

In an attempt to obtain further information which might have some bearing on the metabolism of ascorbic acid during the postoperative period, we decided to study the response of the blood level and urinary excretion of vitamin C after the intravenous administration of test doses of 1,000 mg. of crystalline

cevิตamic acid dissolved in 20 cc. of normal saline, before and after operation. What might be called a vitamin C clearance curve was obtained by determining the fasting plasma level and the apparent rate of removal as indicated by values obtained at intervals after a standard amount of vitamin had been administered intravenously. Such studies were carried out on 14 patients.

In selecting these cases, we have chosen patients who had noninfectious lesions and who were afebrile. They were all candidates for major surgical procedures, although some of them proved to have inoperable malignancy and had only a simple exploratory celiotomy or exploration and colostomy. The ages, diagnoses, type of operation and anesthesia are shown in Table II.

TABLE II

Case No.	Age	Diagnosis	Operation	Anesthesia
1.	33	Duodenal ulcer	Excision of ulcer	Ether
2.	23	Duodenal ulcer	Posterior gastro-enterostomy	Ether
3.	20	Duodenal ulcer	Posterior gastro-enterostomy	Ether
4.	30	Duodenal ulcer	Pólya resection	Spinal
5.	53	Ca. stomach	Pólya resection	Ether
6.	55	Ca. stomach	Exclusion and Pólya anastomosis	Spinal
7.	59	Ca. stomach	Exploration. Biopsy	Ether
8.	58	Ca. stomach	Pólya resection	Ether
9.	66	Ca. rectum	Loop colostomy	Ether
10.	45	Ca. rectum	Loop colostomy	Ether
11.	60	Ca. rectum	(1) Groin dissection (2) Abdominoperineal resection	Ether
12.	64	Ca. rectum	Abdominoperineal resection	Spinal and ether
13.	68	Ca. sigmoid	Resection	Ether
14.	43	Exophthalmic goiter	Hemithyroidectomy	Nitrous oxide

The preoperative blood clearance curves which we obtained are similar to those of Wright and his coworkers¹² and to those of Sloan,¹¹ and show the same variation in contour, depending to some extent on the degree of vitamin C depletion of the individual as shown by the fasting blood level. The curves on our 14 patients, together with three normal controls, are shown in Chart 3.

Sloan's work is particularly interesting, because the order of magnitude of his determinations, made 15 minutes after the test dose, is the same as those obtained by Wright and by ourselves. He made, in addition, some determinations, at shorter intervals after the initial dose, which indicate that the blood level immediately after injection is much higher, reaching 27.4 mg. per cent in one case. This is significant because it indicates that at the 15-minute interval the blood level is falling so rapidly that any slight delay in obtaining this blood sample might be enough to allow the blood level to change somewhat. We feel that this must be kept in mind in interpreting the 15-minute values. At the end of one hour the curve has flattened out sufficiently to make the time factor less important.

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When an intravenous dose of 1,000 mg. of cevitamic acid is given on several days in close succession, the fasting plasma level tends to rise, as would be expected. Simultaneously the peak of the curve becomes higher and its rate of fall slower. The tendency is toward the pattern of the curves shown by the normal controls.

The clearance curves obtained after operation show, in some cases, a marked change in contour. In other cases the change was less marked and in some, entirely absent. When present, these changes appeared usually on the second or third postoperative day and persisted for several days, sometimes as long as a week. The change in contour consists in a lowering of the peak

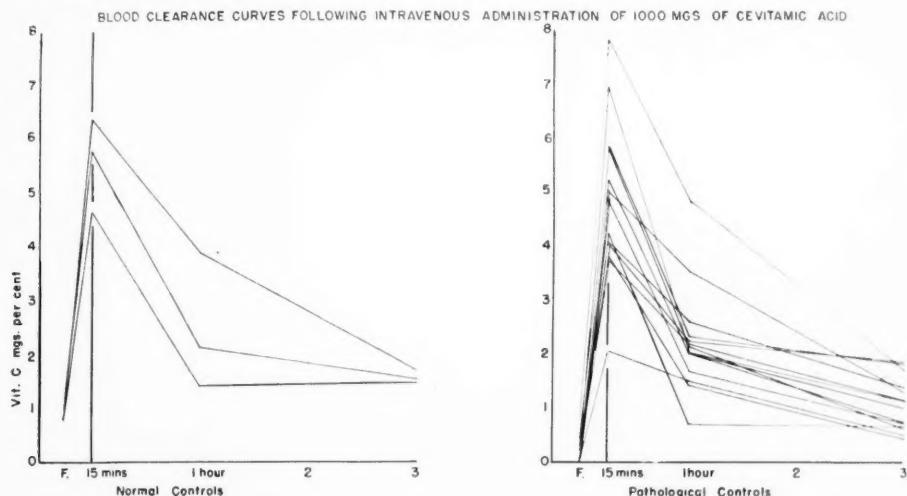


CHART 3.—Blood clearance curves were obtained by giving 1,000 mg. of cevitamic acid dissolved in 20 cc. of normal saline intravenously. The blood plasma vitamin C was determined before and at intervals of 15 minutes, one, two and three hours after administration. The curves obtained on three normal controls are shown at the left, and those on the 14 patients studied appear on the right. The disease conditions from which these patients were suffering are shown in Table II.

to which the blood level rises immediately after the injection of vitamin C and a more rapid fall toward the starting level. The whole curve becomes flattened and tends to lose the characteristic shape of the control curves.

All the data on these patients appear in the protocols appended to each case report, and no attempt has been made to show graphically all the curves obtained. Only typical curves, before and after operation, are given to illustrate the variations which occur. Thus, Chart 4 shows the curves on Case 2, and Chart 7 those on Case 11, both of whom show a marked change in the contour of their postoperative curves. Case 4, whose curves appear in Chart 5, showed only moderate postoperative curve changes, while no change at all is found in the curves following operation in Case 10, as shown in Chart 6.

ABBREVIATED CASE REPORTS AND PROTOCOLS

Case 1.—A male, age 33, was admitted to the hospital, following a massive hemorrhage from a duodenal ulcer. On admission, his red blood cell count was 1,800,000 and

hemoglobin 40 per cent. His preoperative blood cevitamic acid was low on two determinations (0.14 and 0.07 mg. per cent). The bleeding failed to stop, and an excision of the bleeding duodenal ulcer and posterior gastro-enterostomy were performed under nitrous oxide and ether anesthesia.

Protocol: Case 1

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
1/8/38	Fasting	0.14	7.8	
1/9/38			21.5	
1/10/38	Fasting	0.07		1,000 I.V.
	15 mins.	5.21		
	1 hr.	2.04	72.9	
Clearance curve	3 hrs.	0.78		
	5 hrs.	0.67	211.9	
	7 hrs.	0.61		
	7-24 hrs.		6.8	
1/11/38	Fasting	0.27	9.5	
1/12/38	Fasting	0.07	14.9	
1/13/38	Fasting	0.49	11.2	
1/14/38	Fasting	0.34		Operation
1/15/38	Fasting	0.24		
1/16/38			358.2	1,000 I.V.
1/17/38	Fasting	0.52		1,000 I.V.
	15 mins.	1.81		
	1 hr.	1.09		
Clearance curve	3 hrs.	0.97	194.3	
	5 hrs.	0.89		
	7 hrs.	0.83	27.4	
	7-24 hrs.		64.0	
1/18/38	Fasting	0.55	664.1	1,000 I.V.
1/19/38	Fasting	0.78		1,000 I.V.
1/20/38			342.5	
1/21/38	Fasting	0.74	913.7	1,000 I.V.
1/22/38	Fasting	0.79		1,000 I.V.
1/23/38				1,000 I.V.
1/24/38	Fasting	0.97	570.3	1,000 I.V.
1/25/38	Fasting	1.06	49.8	1,000 I.V.
1/26/38	Fasting	1.01	315.9	1,000 I.V.
1/27/38	Fasting	1.02		1,000 I.V.
	15 mins.	6.69		
	1 hr.	3.83		
Clearance curve	3 hrs.	1.42		
	5 hrs.	1.13	239.4	
	7 hrs.	1.07	5.7	
	7-24 hrs.		6.7	
1/28/38	Fasting	0.68		

The preoperative clearance curve is normal in contour, with a peak rising to 5.21 mg. per cent. The curve on the third day after operation is markedly flattened, rising to 1.81 mg. per cent. No further curves were done until 13 days after operation. During this time he had received 11 doses of 1,000 mg. of cevitamic acid intravenously. The fasting blood level rose to 1.02 mg. per cent, and the curve regained its normal contour.

It is interesting to note that the amount of cevitamic acid excreted in the urine after the administration of 1,000 mg. of cevitamic acid intravenously was only slightly greater on the second day after operation and slightly lower on the third postoperative day, than the preoperative output had been, although the fasting blood level was higher after operation due to the vitamin C administered.

Case 2.—A male, age 23, was admitted to the hospital, for an obstructing duodenal ulcer. His physical condition was good except for a recent loss of five pounds in weight. Blood examination showed a red blood cell count of 4,350,000 with a hemoglobin of 80 per cent. His blood cevitamic acid level was low (0.07 mg. per cent), and the pre-operative clearance curve was normal. A posterior gastro-enterostomy was performed under nitrous oxide-ether anesthesia.

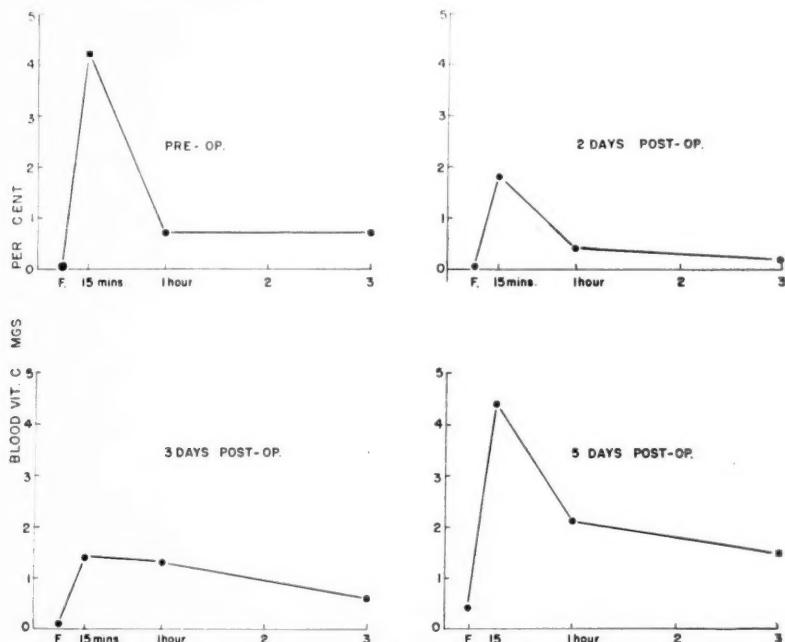


CHART 4.—Case 2: The vitamin C clearance curves before operation and on the second, third and fifth postoperative days are shown. A marked change in contour occurs on the second and third postoperative day, but on the fifth day after operation the curve has returned essentially to normal.

During the first 12 days after operation, ten doses of 1,000 mg. of vitamin C were given intravenously. The curves on the second and third days after operation show marked flattening, while that on the fifth day has returned essentially to normal (Chart 4).

The fasting blood level rises after operation in response to the administration of vitamin C, but the urinary output of cevitamic acid following the intravenous administration of 1,000 mg. of cevitamic acid shows only a slight increase after operation over the amount excreted preoperatively.

Protocol: Case 2

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
1/15/38	Fasting	0.07		
1/16/38			28.4	
1/17/38			26.9	
1/18/38				1,000 I.V.

Protocol: Case 2 (Continued)

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
Clearance curve	15 mins.	4.23		
	1 hr.	0.71		
	3 hrs.	0.68	239.8	
	5 hrs.	0.22	12.4	
	7 hrs.	0.18	19.5	
	Fasting	0.18	3.2	
1/20/38	Fasting	0.07	12.7	
1/21/38			20.4	
1/22/38				
1/23/38				
1/24/38	Fasting	0.07	15.7	
1/25/38			20.8	
1/26/38			20.3	
1/27/38			10.8	
1/28/38			8.7	
1/29/38				
1/30/38			3.1	
1/31/38	Fasting	0.02	11.5	
2/ 1/38			23.0	
2/ 2/38			10.9	Operation
2/ 3/38	Fasting	0.02	9.7	
2/ 4/38	Fasting	0.07		1,000 I.V.
Clearance curve	15 mins.	1.79		
	1 hr.	0.37		
	3 hrs.	0.21	74.1	
2/ 5/38	Fasting	0.11		1,000 I.V.
Clearance curve	15 mins.	1.42		
	1 hr.	1.29		
	3 hrs.	0.61		
2/ 6/38			447.1	
2/ 7/38	Fasting	0.35		1,000 I.V.
Clearance curve	15 mins.	4.40		
	1 hr.	2.10		
	3 hrs.	1.47	161.8	
	3-24 hrs.		265.1	
2/ 8/38	Fasting	0.64	320.6	1,000 I.V.
2/ 9/38	Fasting	0.61	28.2	1,000 I.V.
2/10/38	Fasting	0.44		1,000 I.V.
Clearance curve	15 mins.	5.07		
	1 hr.	1.42	208.7	
	3 hrs.	1.45	31.6	
2/11/38	Fasting	0.54		1,000 I.V.
2/12/38				1,000 I.V.
2/13/38			34.7	1,000 I.V.
2/14/38			2.3	1,000 I.V.
2/15/38			5.3	

Case 3.—A male, age 20, was admitted to the hospital, because of a duodenal ulcer which could not be controlled on a medical regimen. He was in excellent general condition, had lost no weight, and showed a red blood cell count of 4,890,000 with a hemoglobin of 90 per cent. His initial blood cevitamic acid level was low (0.12 mg. per cent).

A subtotal gastrectomy and posterior Pólya anastomosis were performed under

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nitrous oxide-ether anesthesia. He received 1,000 mg. of cevitamic acid intravenously each day for four days before and for four days after operation. His fasting blood level was 0.54 mg. per cent on the morning of operation.

The clearance curve on the day after operation shows marked flattening, but on the third day a normal curve was obtained. The extent and duration of the postoperative changes are much less than in Case 2, who was also a young man in good physical condition, but who had an even lower initial cevitamic acid level, and received no preoperative medication with vitamin C. These changes are also less marked than in Case 13, who had a similar initial blood level and received preoperative vitamin C, but who was older and in poorer general physical condition.

There is some increase in the amount of vitamin C excreted in the urine following the intravenous administration of 1,000 mg. of cevitamic acid during the postoperative interval. This is not more than can be attributed to the higher fasting blood level.

Protocol: Case 3

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
2/24/38	Fasting	0.12		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	5.82 2.02 1.02 9.5	
2/25/38			69.8	
2/26/38			148.3	
2/27/38				1,000 I.V.
2/28/38	Fasting	0.54	13.9	1,000 I.V.
3/ 1/38	Fasting	0.25	10.6	Operation
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	2.86 1.01 0.53 7.0	1,000 I.V.
3/ 2/38	Fasting	0.41	104.6	1,000 I.V.
3/ 3/38	Fasting	0.66	516.5	1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	7.51 1.78 0.98 149.1	
3/ 4/38	Fasting	0.69	339.6	1,000 I.V.
3/ 5/38	Fasting	0.80		
3/ 6/38				
3/ 7/38			289.2	
3/ 8/38			54.5	
3/ 9/38				
3/10/38	Fasting	0.84		
3/11/38	Fasting	0.73		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	4.95 1.83 1.32 106.3	

Case 4.—A male, age 30, was admitted to the hospital, who was in good physical condition, notwithstanding that he was suffering from a partial pyloric obstruction resulting from a duodenal ulcer. There was no history of weight loss. His red blood

cell count was 5,000,000 and hemoglobin 90 per cent. He had an initial blood cevitamic acid level of 0.29 mg. per cent.

The first clearance curve was done while he was receiving 3,000 to 4,000 cc. of parenteral fluid daily. Following this, a jejunostomy was performed for feeding, and parenteral fluid was discontinued. Ten days later, another clearance curve was done. It is almost identical with the first one and we believe is strong evidence against the influence of even large amounts of parenteral fluid on these curves.

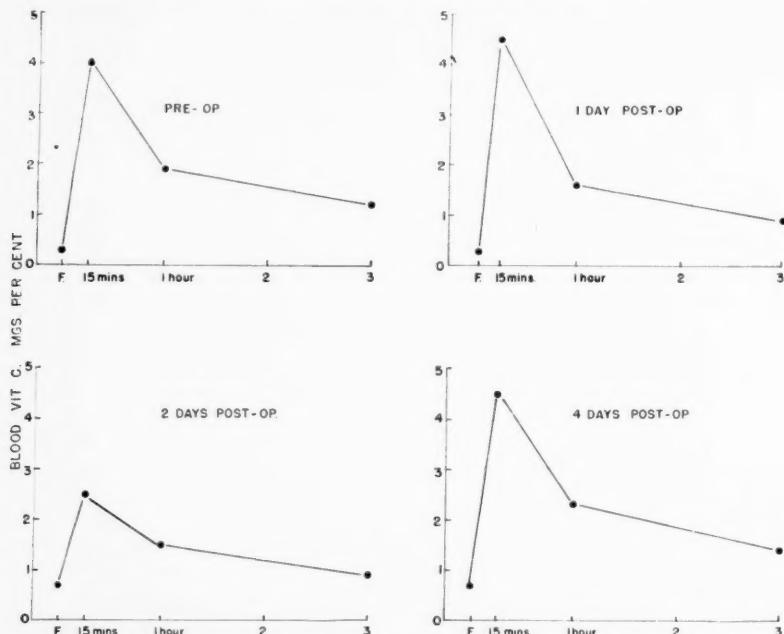


CHART 5.—Case 4: Vitamin C clearance curves were obtained on this patient before operation and on the first, second and fourth postoperative days. A change in contour of the curve is seen, only, in the one obtained on the second day after operation.

At operation, a subtotal gastrectomy with a posterior Pólya anastomosis was performed. The clearance curve on the first day after operation shows no change. On the second day the curve is definitely flattened, but it has resumed its normal contour on the fourth day (Chart 5).

There is no significant increase in the amount of vitamin C excreted in the urine after the intravenous administration of 1,000 mg. of cevitamic acid after operation.

Protocol: Case 4

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
4/22/38	Fasting	0.29		1,000 I.V.
	Clearance curve	15 mins. 1 hr. 3 hrs. 3-24 hrs.	4.21 2.01 1.16 88.1	114.0
4/23/38	Fasting	0.47	7.4	
4/24/38			28.2	
4/25/38				Operation (1)
4/26/38				
4/27/38				

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Protocol: Case 4 (Continued)

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
4/28/38				
4/29/38				
4/30/38				
5/ 1/38				
5/ 2/38				
5/ 3/38				
5/ 4/38				
5/ 5/38				
5/ 6/38	Fasting	0.26		
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	3.95 1.86 1.18	1,000 I.V.
			255.9	
5/ 7/38				
5/ 8/38				
5/ 9/38				
5/10/38			2.5	Operation (2)
5/11/38	Fasting	0.25		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	4.54 1.64 0.87	60.7
5/12/38	Fasting	0.70		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	2.54 1.47 0.85	198.2 2.9
5/13/38			52.7	
5/14/38	Fasting	0.66		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	4.54 2.28 1.38	213.7

Case 5.—A male, age 53, was admitted to the hospital, in fair general condition, except for a recent weight loss of 25 pounds. Roentgenologic examination showed a large, ulcerated lesion on the lesser curvature of the stomach. His red blood cell count was 4,250,000, and hemoglobin 75 per cent. His fasting blood cevitamic acid was low (0.14 and 0.10 mg. per cent), and the preoperative curve was normal in shape.

At operation, a subtotal gastric resection for a carcinoma of the stomach was performed, under nitrous oxide-ether anesthesia. The clearance curve on the fourth day after operation shows the typical flattening and rose only to 1.05 mg. per cent. Following this he received 200 mg. of cevitamic acid intravenously for 13 days, with a considerable rise in the fasting blood level. A curve done 18 days after operation shows a normal result.

The amount of cevitamic acid recovered from the urine, after the administration of 1,000 mg. intravenously, was less on the fifth postoperative day than before operation.

Protocol: Case 5

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
1/12/38	Fasting	0.14	12.0	
1/13/38	Fasting	0.10		1,000 I.V.

Protocol: Case 5 (Continued)

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
Clearance curve	15 mins.	4.90		
	1 hr.	1.71		
	3 hrs.	0.78		
	5 hrs.	0.73	87.3	
	7 hrs.	0.33		
	7-24 hrs.		72.5	
	Fasting	0.17	12.4	
1/14/38				
1/15/38	Fasting	0.27		
1/16/38				
1/17/38	Fasting	0.11		
1/18/38	Fasting	0.15		
1/19/38	Fasting	0.03	37.8	
1/20/38			16.4	
1/21/38				
1/22/38	Fasting	0.15		
1/23/38				
1/24/38	Fasting	0.17		Operation
1/25/38	Fasting	0.11	12.4	
1/26/38	Fasting	0.11	19.0	
1/27/38	Fasting	0.07	19.4	
1/28/38	Fasting	0.11		1,000 I.V.
Clearance curve	15 mins.	1.05		
	1 hr.	0.35		
	3 hrs.	0.17	69.3	
	5 hrs.	0.04		
	7 hrs.	0.07	28.0	
	7-24 hrs.		20.0	
	Fasting	0.07		
1/29/38				200 I.V.
1/30/38			3.1	200 I.V.
1/31/38	Fasting	0.04	25.0	200 I.V.
2/ 1/38	Fasting	0.31	35.6	200 I.V.
2/ 2/38	Fasting	0.35	26.2	200 I.V.
2/ 3/38	Fasting	0.51	15.5	200 I.V.
2/ 4/38	Fasting	0.48	49.1	200 I.V.
2/ 5/38	Fasting	0.73		200 I.V.
2/ 6/38			77.4	200 I.V.
2/ 7/38	Fasting	0.75	75.8	200 I.V.
2/ 8/38	Fasting	0.52	13.5	200 I.V.
2/ 9/38	Fasting	0.70	97.6	200 I.V.
2/10/38	Fasting	0.69	97.9	200 I.V.
2/11/38	Fasting	0.63		1,000 I.V.
Clearance curve	15 mins.	8.69		
	1 hr.	5.08		
	3 hrs.	1.60		
	5 hrs.	1.33		
	7 hrs.	1.09		
2/12/38	Fasting	0.61		

Case 6.—A male, age 55, entered the hospital, with a roentgenologic diagnosis of carcinoma of the stomach. He was in good general condition except for a moderate secondary anemia. His red blood cell count was 3,640,000 and hemoglobin 60 per cent. He had an initial blood cevitamic acid level of 0.40 mg. per cent. At operation, per-

VITAMIN C IN SURGICAL PATIENTS

formed under spinal anesthesia, the growth was found to be inoperable and an exclusion operation with a Pólya anastomosis was performed. Following operation he received 1,000 mg. of crystalline cevitamic acid daily.

The curve on the first day after operation shows definite flattening and the one on the third postoperative day shows some. These changes are less marked than in Case 13, which we believe to be due to his better general condition and higher initial cevitamic acid level. His behavior is very similar to that of Case 3.

Protocol: Case 6

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
2/24/38	Fasting	0.40		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	4.04 2.29 1.88 4.1	
2/25/38			10.8	
2/26/38				
2/27/38			19.5	
2/28/38			9.9	1,000 I.V.
3/ 1/38				Operation
3/ 2/38	Fasting	0.24		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	2.84 1.58 0.68 604.7	
3/ 3/38	Fasting	0.57	411.8	1,000 I.V.
3/ 4/38	Fasting	0.78		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	3.86 1.87 1.51 269.7	
3/ 5/38	Fasting	0.72		1,000 I.V.
3/ 6/38				
3/ 7/38				
3/ 8/38			100.1	1,000 I.V.
3/ 9/38			45.8	
3/10/38	Fasting	0.55	18.3	
3/11/38			12.1	

Case 7.—A male, age 59, entered the hospital, with a roentgenologic diagnosis of extensive carcinoma of the stomach. He was in fair general condition. His blood showed a red blood cell count of 3,550,000 with a hemoglobin of 50 per cent. He stated that he had lost ten pounds during the past year. He had an initial blood cevitamic acid of 0.07 mg. per cent.

Operation consisted of an exploratory celiotomy and biopsy of an inoperable gastric neoplasm. During the first six days after operation four doses of 1,000 mg. of cevitamic acid were given intravenously. The clearance curve on the first day after operation was essentially unchanged. On the third day the curve is flattened, but on the fourth day it had returned to its normal shape.

The amount of vitamin C excreted in the urine after the intravenous administration of 1,000 mg. of cevitamic acid does not become greater than the excretion before operation until the fourth postoperative day, and corresponds with a considerable rise in the fasting blood level.

Protocol: Case 7

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
4/28/38	Fasting	0.07		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	{ 2.07 1.53 0.45 38.0 3.4	
4/29/38				Operation
4/30/38	Fasting	0.15		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	{ 3.58 1.91 1.03 37.8	
5/ 1/38			17.9	
5/ 2/38	Fasting	0.19		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	{ 1.50 1.27 0.74 31.8	
5/ 3/38	Fasting	0.37		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	{ 3.65 1.66 1.10 449.4 22.5	
5/ 4/38				
5/ 5/38	Fasting	0.66		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	{ 3.07 1.89 1.23 123.8 185.3 12.7	
5/ 6/38				

Case 8.—A male, age 58, entered the hospital, with a roentgenologic diagnosis of carcinoma of the stomach. He was in good general condition except for a secondary anemia of moderate degree. His red blood cell count was 3,400,000 and hemoglobin 50 per cent. There was no history of recent weight loss. His initial blood cevitamic acid level was 0.47 mg. per cent.

At operation, a subtotal resection of the stomach with a posterior Pólya anastomosis was performed. There is flattening of the clearance curves on the second and third days after operation, although the latter is tending to resume a normal contour. The duration of the changes in the clearance curves is less here than in similar patients whose vitamin C depletion is more marked (Cases 2 and 5).

On the second day after operation less vitamin C was excreted in response to the intravenous administration of 1,000 mg. of cevitamic acid than before operation.

Protocol: Case 8

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
6/18/38	Fasting	0.47		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	{ 5.84 2.38 1.85 368.0	
6/19/38				

VITAMIN C IN SURGICAL PATIENTS

Protocol: Case 8 (Continued)

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
6/20/38			4.0	
6/21/38				
6/22/38	Fasting	0.24		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	2.38 1.52 0.51	
		3-24 hrs.	288.4	
6/23/38	Fasting	0.41		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	4.73 1.85 1.13	

Case 9.—A male, age 66, had had an exploratory celiotomy and loop colostomy performed for inoperable carcinoma of the rectum. He was in good general condition except for a recent weight loss of ten to 15 pounds. Blood studies showed his red blood cell count to be 4,470,000, and the hemoglobin 75 per cent. He had an initial blood cevitamic acid level in the low normal range (0.66 and 0.87 mg. per cent).

The clearance curves after operation show no flattening. In fact, the one on the second day has an exceptionally high peak.

The urinary excretion of vitamin C after the intravenous administration of 1,000 mg. of cevitamic acid is somewhat greater on the second and third days after operation than preoperatively, but on the eleventh postoperative day it is less.

Protocol: Case 9

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
3/15/38	Fasting	0.66	4.2	
3/16/38	Fasting	0.87		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	7.80 4.81 1.74	
		3-24 hrs.	74.8 162.0	
3/17/38	Fasting	1.41	10.6	
3/18/38			3.8	
3/19/38				
3/20/38			0.9	
3/21/38				Operation
3/22/38	Fasting	0.58		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	8.03 6.36 2.45	
		3-24 hrs.	31.4	
3/23/38	Fasting	0.75		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	13.46 6.70 4.64	
		3-24 hrs.	65.1 171.3 195.0	
3/24/38	Fasting	1.27		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	8.68 5.99 1.87	
		3-24 hrs.	641.7	

Protocol: Case 9 (Continued)

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
3/25/38			161.0	
3/26/38				
3/27/38			197.0	
3/28/38			109.8	
3/29/38			115.2	
3/30/38			34.9	
3/31/38			34.7	
4/ 1/38	Fasting	0.68		1,000 I.V.
	Clearance curve	{ 15 mins. 4.02 1 hr. 3.33 3 hrs. 1.90 3-24 hrs.	295.7	

Case 10.—A male, age 45, was very similar to Case 9, except that he was younger, and had a lower initial blood level (0.34 mg. per cent). His general physical condition was good. There had been no recent loss of weight. His blood showed a red blood cell count of 4,320,000 with a hemoglobin of 80 per cent. He had an exploratory celiotomy and loop colostomy for inoperable carcinoma of the rectum. There is no flattening of the clearance curves after operation (Chart 6).

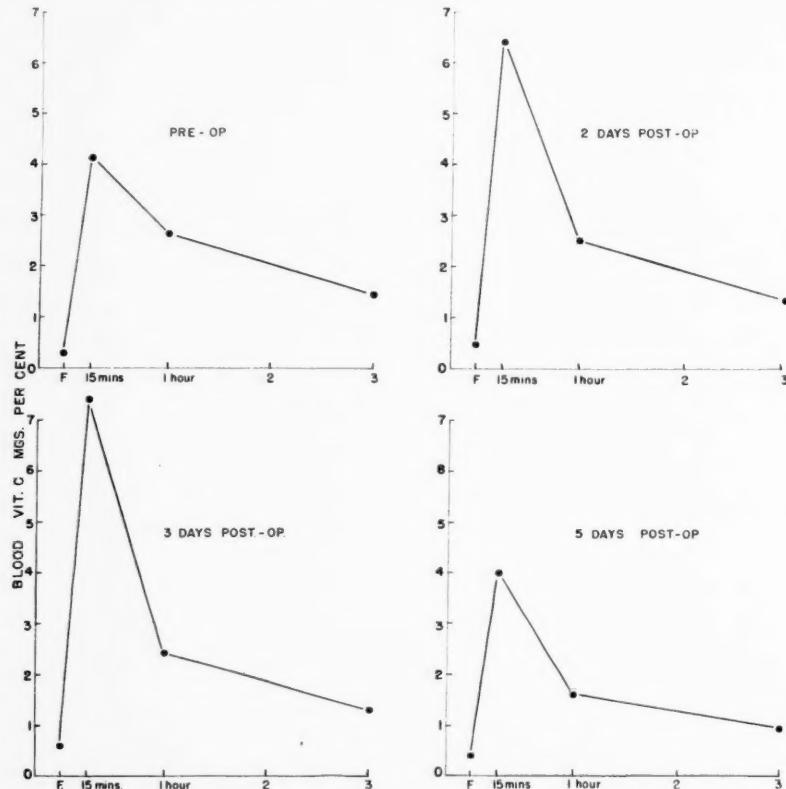


CHART 6.—Case 10: Vitamin C clearance curves were obtained before operation and two, three and five days after operation. There is no flattening of the peak of the post-operative curves, and, in fact, those on the second and third days after operation show a greater rise than before operation. This can be attributed in our opinion to the repeated intravenous administration of a large dose of cevitanic acid, and does not occur, in our experience, when a more extensive surgical procedure is carried out.

VITAMIN C IN SURGICAL PATIENTS

Protocol: Case 10

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
3/26/38	Fasting	0.34		
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	4.07 2.64 1.40	109.1
3/27/38				14.7
3/28/38	Fasting	0.47		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	6.39 2.50 1.25	8.4
3/29/38	Fasting	0.57		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	7.44 2.40 1.32	351.4 22.2
3/30/38				
3/31/38	Fasting	0.37		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	4.03 1.58 0.91	206.7 12.6
4/1/38				3.9

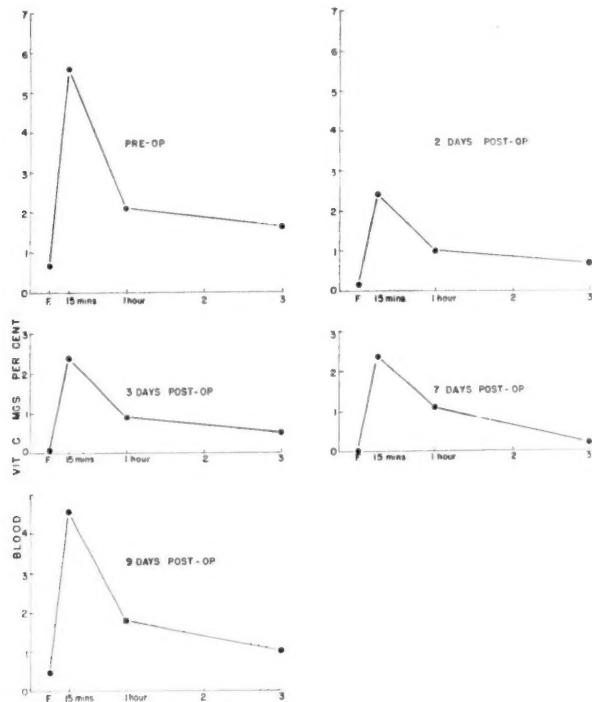


CHART 7.—Case 10: The vitamin C clearance curves obtained before operation and on various postoperative days are shown. Following operation there is a marked change in contour in these curves which persists until the ninth postoperative day.

Case 11.—A male, age 60, who entered the hospital because of a carcinoma of the rectum, is particularly instructive because he was subjected to two separate operative procedures, the second of much greater magnitude than the first.

He was in fair general condition, but had lost ten pounds in the past year. His blood showed a red blood cell count of 4,960,000 with a hemoglobin of 90 per cent. His initial blood cevitamic acid was 0.11 mg. per cent. The first operation was a biopsy of a rectal growth and a unilateral groin dissection. Clearance curves done on the second and fourth days after this operation show no flattening, and their peaks rise successively higher as the fasting blood level increases.

Eleven days after the first operation, a combined abdominoperineal resection of a rectal carcinoma was carried out. Following this there is marked flattening of the clearance curve, which persists until the seventh postoperative day. On the ninth day after operation the curve has returned essentially to normal (Chart 7).

Protocol: Case 11

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
5/26/38			7.1	
5/27/38	Fasting	0.11		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	3.77 2.21 1.15 48.2 10.8	
5/28/38				
5/29/38				
5/30/38			6.4	
5/31/38			2.8	
6/ 1/38			7.3	
6/ 2/38				Operation (1)
6/ 3/38			1.7	
6/ 4/38	Fasting	0.07		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	4.90 2.08 1.22	
6/ 5/38			121.5	
6/ 6/38	Fasting	0.55	44.2	1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	6.09 3.58 1.71 264.7	
6/ 7/38				
6/ 8/38			7.4	
6/ 9/38			6.0	
6/10/38	Fasting	0.71		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	5.63 2.07 1.58	
6/11/38			215.0	
6/12/38				
6/13/38				Operation (2)
6/14/38				
6/15/38	Fasting	0.24		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	2.42 1.01 0.56	
6/16/38	Fasting	0.14		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	2.40 0.92 0.51	

VITAMIN C IN SURGICAL PATIENTS

Protocol: Case 11 (Continued)

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
6/17/38				
6/18/38				
6/19/38				
6/20/38	Fasting	0.04		
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	2.40 1.06 0.21	1,000 I.V.
6/21/38				
6/22/38	Fasting	0.45		
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	4.46 1.75 1.02	1,000 I.V.

The increase in the amount of vitamin C excreted in the urine after operation in response to the intravenous administration of 1,000 mg. of cevitamic acid is in proportion to the rise in the fasting blood level.

Case 12.—A male, age 64, entered the hospital, suffering from a carcinoma of the rectum. He had lost 35 pounds during the past eight months. His red blood cell count

Protocol: Case 12

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
6/ 9/38	Fasting	0.07		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	6.93 2.19 0.66	
6/10/38	3-24 hrs.		175.6	
6/11/38			40.4	Operation
6/12/38				
6/13/38	Fasting	0.04		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	1.76 1.48 0.56	
6/14/38	Fasting	0.04		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	1.74 1.40 0.90	
6/15/38				
6/16/38				
6/17/38				
6/18/38				
6/19/38				
6/20/38				
6/21/38				
6/22/38				
6/23/38				
6/24/38				
6/25/38				
6/26/38				
6/27/38	Fasting	0.17		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	3.76 1.90 0.98	

was 3,300,000 and hemoglobin 80 per cent. His initial blood cevitamic acid was 0.07 mg. per cent.

The clearance curves on the second and third days after an abdominoperineal resection of the rectum show typical flattening. He had a very stormy convalescence and was considered too ill for further studies.

A final curve was done on the sixteenth day after operation and shows a fairly normal contour, although the peak is somewhat lower than the original preoperative curve.

Case 13.—A male, age 68, entered the hospital, for resection of the sigmoid for carcinoma. He was in fairly good general condition except for a weight loss of 15 pounds. His red blood cell count was 4,400,000 and hemoglobin 80 per cent.

His initial level of blood cevitamic acid was 0.14 mg. per cent, and the first clearance curve is normal for this starting level. He then received ten intravenous doses of 1,000 mg. of cevitamic acid each. This brought his fasting blood level up into the normal range and a second clearance curve showed a somewhat higher peak than the first one.

After operation, which was a resection of the sigmoid, under nitrous oxide-ether anesthesia, the curves on the second and fourth days are flattened, while that on the sixth day after operation has regained its normal contour.

The marked drop in the fasting blood level as well as the flattening of the peaks of the clearance curves, in spite of the daily administration of large intravenous doses of Vitamin C, both before and after operation, make this case of particular interest.

There is no marked increase in the excretion of vitamin C following the intravenous administration of 1,000 mg. of cevitamic acid after operation. The excretion increases gradually as the fasting blood level rises.

Protocol: Case 13

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
2/9/38	Fasting	0.14		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	3.83 1.44 0.51 131.0 10.8	
2/10/38	Fasting	0.04	6.3	1,000 I.V.
2/11/38			223.5	1,000 I.V.
2/12/38				1,000 I.V.
2/13/38			508.4	1,000 I.V.
2/14/38	Fasting	0.97		1,000 I.V.
2/15/38			5.0	1,000 I.V.
2/16/38			283.5	1,000 I.V.
2/17/38			33.4	1,000 I.V.
2/18/38	Fasting	0.77		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs. 3-24 hrs.	4.58 2.67 1.65 203.8 8.2	
2/19/38				Operation
2/20/38			9.0	1,000 I.V.
2/21/38	Fasting	0.36		1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	2.84 1.78 0.88	
2/22/38			237.1	
2/23/38	Fasting	0.08	100.8	1,000 I.V.
	Clearance curve	{ 15 mins. 1 hr. 3 hrs.	1.71 1.14 0.55	1,000 I.V.
			254.1	

VITAMIN C IN SURGICAL PATIENTS

Protocol: Case 13 (Continued)

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
2/24/38	Fasting	0.29	279.5	1,000 I.V.
2/25/38	Fasting	0.32		1,000 I.V.
Clearance curve	15 mins. 1 hr. 3 hrs. 3-24 hrs.	4.73 1.91 1.04	231.9 90.0	
2/26/38				1,000 I.V.
2/27/38			489.0	1,000 I.V.
2/28/38			160.9	1,000 I.V.
3/ 1/38			53.4	
3/ 2/38	Fasting	0.44	604.8	1,000 I.V.
3/ 3/38			133.3	
3/ 4/38			22.6	
3/ 5/38				
3/ 6/38				
3/ 7/38				
3/ 8/38	Fasting	0.26	26.5	
3/ 9/38			10.4	
3/10/38	Fasting	0.31		

Case 14.—This case is interesting because she was a woman, age 43, with exophthalmic goiter, who had been carried on iodine for two years. During this time her basal metabolic rate had gradually risen from about +20 to +50, and she was finally admitted to the hospital for thyroidectomy. She had lost 20 pounds during the past year. Her blood examination showed a red blood cell count of 3,583,000 and a hemoglobin of 70 per cent. Her initial blood cevitamic acid was 0.29 mg. per cent.

The clearance curve before operation is normal in contour and those after operation show no significant change.

Protocol: Case 14

Date	Time	Blood Vit. C Mg. Per Cent	Urine Vit. C Mg.	Dosage Mg.
5/3/38			5.8	
5/4/38	Fasting	0.29		1,000 I.V.
Clearance curve	15 mins. 1 hr. 3 hrs. 3-24 hrs.	5.01 3.57 1.31	10.3 2.2	
5/5/38				Operation
5/6/38	Fasting	0.26		1,000 I.V.
Clearance curve	15 mins. 1 hr. 3 hrs. 3-24 hrs.	4.63 1.62 0.95	156.6 11.9	
5/7/38	Fasting	0.62		1,000 I.V.
Clearance curve	15 mins. 1 hr. 3 hrs.	6.17 2.33 1.16	271.7 150.6	
5/8/38				
5/9/38	Fasting	1.01	23	

Discussion.—In attempting to interpret these changes in the behavior of vitamin C during the postoperative interval, there are a number of factors which must be considered. The general state of nutrition of the patient, especially with reference to the degree of vitamin C depletion, and the effect on the plasma cevitamic acid level of partial starvation during the days immediately after operation must certainly be considered, as well as the type of anesthesia, the extent and duration of the surgical procedure and the amount of parenteral fluid administered during and after operation.

We feel that the consistent fall in the plasma vitamin C observed after operation cannot be accounted for entirely on the basis of decrease in vitamin C intake. Most of the patients on whom these observations were made (Chart 1) were allowed fluids by mouth, including fresh fruit juice, immediately after operation, so that an adequate supply of vitamin C was available throughout the postoperative interval. In addition, several of the cases showed a drop in the plasma vitamin C which is far too abrupt to be accounted for on the basis of starvation alone, even if the diet after operation contained no vitamin C.

It does not seem that the changes in contour observed in the clearance curves after operation can be attributed to a decrease in vitamin C intake. As a study of the protocols will show, a number of the patients showed higher fasting plasma vitamin C levels, due to previous administration of cevitamic acid, when the postoperative clearance curves were made, and yet the curves showed the changes in contour described. These changes appear, although the intake of vitamin C has been greater than that provided by the patient's usual diet, as shown by the rise in plasma cevitamic acid level.

We believe that we have evidence that the amount of parenteral fluid administered and the type of anesthesia are not of great importance in producing the changes in the clearance curves following operation. The first curve on Case 4 was done while this patient was receiving 3,000 to 4,000 cc. of intravenous fluid daily, and the second curve after parenteral fluid had been replaced by jejunostomy feedings. Reference to the protocol on this patient will show the close similarity of these curves, which we think affords adequate proof that parenteral fluid does not play an important part in altering the pattern of the clearance curves.

Some of these patients were operated upon under spinal anesthesia and others under ether. The similarity of the changes in the postoperative clearance curves, when comparable operations were performed, as illustrated in the protocols, seems to indicate that these changes are independent of the type of anesthesia.

There is some evidence which suggests that the magnitude of the surgical procedure bears a relationship to the extent and duration of the postoperative alteration in the curves. One of our cases in particular seems to lend direct evidence on this point. Case 11 had two operations. The first was a biopsy of a rectal growth and a unilateral groin dissection. The curves before, and on the second and third days after, this operation are essentially alike and show no significant postoperative change. The second operation was an

abdominoperineal resection of the rectum, performed 11 days after the first operation. Following this operation, the tolerance curves show a marked and typical flattening (Chart 7) which persists until the curve obtained on the ninth day after operation.

The general nutritional state and especially the degree of vitamin C depletion seems to be another important factor. The three patients whose post-operative curves show no change (Cases 9, 10 and 14) were all in relatively good physical condition, and not as markedly depleted in vitamin C as some of the other cases studied (0.66 mg.; 0.34 mg.; and 0.29 mg. per cent, respectively). They had relatively little surgery, two having exploratory celiotomies and loop colostomies for inoperable rectal growths and the third, a hemithyroidectomy for exophthalmic goiter. The results obtained in Case 7 are of interest in this regard. This man, in rather poor general condition and markedly depleted in vitamin C, had only an exploratory celiotomy and biopsy of an inoperable gastric carcinoma. The curve done on the third day after operation shows definite flattening of the type already described.

A study of the protocols of Cases 2 and 3 seems to lend further evidence as to the importance of vitamin C depletion in the changes seen in the clearance curves obtained following operation. The initial blood levels were low in both cases, Case 3 being slightly higher than Case 2. Four daily intravenous doses of 1,000 mg. of cevitamic acid were given to Case 3, and his fasting blood level rose to 0.54 mg. per cent on the day of operation. He was subjected to a more extensive surgical procedure than the other patient, yet his post-operative clearance curves show less marked changes than do those of Case 2.

SUMMARY.—We believe that we have evidence that there is a change in the behavior of vitamin C during the postoperative period. A fall in the fasting plasma level of cevitamic acid occurs immediately after operation, with a gradual return to the preoperative level, and when an intravenous dose of 1,000 mg. of cevitamic acid is given, it is removed from the blood stream more rapidly than before operation.

The possible explanations for these changes would seem to be: Increased excretion; increased destruction in the body; utilization by the body; or storage. We have been unable to detect any increase in excretion following operation. The amount of cevitamic acid excreted in the urine following the administration of doses of 1,000 mg. intravenously is usually less during the first few days after operation than it was before operation. Whether the changes in cevitamic acid metabolism represent increased destruction, utilization in the healing processes or storage in the body cannot be determined at the present time.

CONCLUSIONS

- (1) Many hospital patients show a definite depletion of vitamin C. Fasting, plasma cevitamic acid determinations on 188 patients show that two-thirds of them have a level of less than 0.5 mg. per 100 cc.
- (2) This state of depletion is not limited to any one disease group, and is found in patients with a variety of pathologic conditions.

(3) Following operation, the fasting level of vitamin C in the blood plasma shows a consistent drop, with gradual return to the preoperative value.

(4) There is no increase in the vitamin C excreted in the urine following operation, and the amount excreted in response to a dose of 1,000 mg. of cevิตamic acid given intravenously is not increased after operation.

(5) When 1,000 mg. of cevิตamic acid are given intravenously and the plasma vitamin C determined at intervals of 15 minutes, one hour and three hours, a characteristic clearance curve is obtained.

(6) Following operation the clearance curves may show a marked change in contour. These changes are influenced by the general nutritional state of the patient, by the degree of vitamin C depletion, and by the extent of the surgical procedure. They do not seem to be affected by the type of anesthesia employed or by the amount of parenteral fluid administered.

(7) We suggest that the more rapid clearance from the fasting blood of vitamin C administered intravenously following operation is possibly dependent upon an increased need for this substance in the process of tissue repair and wound healing.

REFERENCES

- ¹ Aschoff, L., and Koch, W.: Scorbust. Eine Pathologisch-Anatomische Studie. Gustav Fisher, Jena, 1919.
- ² Faulkner, J. M., and Taylor, F. H. L.: Vitamin C and Infection. *Ann. Int. Med.*, **10**, 1867-1873, June, 1937.
- ³ Geissendorfer, H.: Excretion of Vitamin C in Surgical Diseases. *Arch. f. Klin. Chir.*, **189**, 276-278, 1937.
- ⁴ Harris, L. T., Ray, S. N., and Ward, A.: The Excretion of Vitamin C in Human Urine and Its Dependence on the Dietary Intake. *Biochem. Jour.*, **27**, 2011-2015, 1933.
- ⁵ Ingalls, T. H., and Warren, H. A.: Asymptomatic Scurvy. *New England Jour. Med.*, **217**, 443-446, September, 1937.
- ⁶ Lanman, T. H., and Ingalls, T. H.: Vitamin C Deficiency and Wound Healing. *ANNALS OF SURGERY*, **105**, 616-625, April, 1937.
- ⁷ Menkin, V., Wolbach, S. B., and Menkin, M. F.: Formation of Intercellular Substance by the Administration of Ascorbic Acid (Vitamin C) in Experimental Scorbustus. *Am. Jour. Path.*, **10**, 569-575, September, 1934.
- ⁸ Mindlen, R. L., and Butler, A. M.: The Determination of Ascorbic Acid in Plasma; a Macromethod and Micromethod. *Jour. Biol. Chem.*, **122**, 673-686, February, 1938.
- ⁹ Pijoan, M., and Klempner, F.: Determination of Blood Ascorbic Acid. *Jour. Clin. Invest.*, **16**, 443-445, May, 1937.
- ¹⁰ Rhinehart, J. F., Greenberg, L. D., Baker, F., Mettier, S. R., Bruckman, F., and Choy, F.: Metabolism of Vitamin C in Rheumatoid Arthritis. *Arch. Int. Med.*, **61**, 537-551, April, 1938.
- ¹¹ Sloan, R. A.: A Comparison of Methods for Detecting and Grading Subclinical Scurvy. *Jour. Lab. and Clin. Med.*, **23**, 1015-1026, July, 1938.
- ¹² Wright, I. S., Lilienfeld, A., and MacLenethen, E.: Determination of Vitamin C Saturation. *Arch. Int. Med.*, **60**, 264-271, August, 1937.
- ¹³ Wolbach, S. B., and Howe, P. R.: Intercellular Substances in Experimental Scorbustus. *Arch. Path. and Lab. Med.*, **1**, 1-24, January, 1936.
- ¹⁴ Wolbach, S. B.: Vitamin C and the Formation of Intercellular Material. *New England Jour. Med.*, **215**, 1158-1159, December, 1936.

MOTOR FUNCTIONS OF THE STOMACH AFTER RESECTION

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IN RECENT years resection of the stomach has been widely accepted, not only as a method of treatment for cancer, but for gastric ulcers as well. Nevertheless, many surgeons are opposed to this operation, believing that the removal of such important parts of the stomach as the pylorus or antrum radically changes all digestive processes in the gastro-intestinal tract, and, therefore, cannot be without bad effects for the whole organism.

The great majority of surgeons who perform gastrectomy apparently pay much more attention to clinical data, or to the technic of the operation, than to the question of the postoperative functions of the gastro-intestinal tract. As a result, the question of how digestion is carried on after gastrectomy, of the manner in which the remaining part of the stomach in its motor and chemical activities (including the liver and pancreas) reacts to gastrectomy, and the problem of the influence of this operation upon the whole organism and upon its blood forming organs, is still far from being solved.

The study of this problem as a whole naturally presents an interesting task for many investigators. The present communication is restricted to an investigation of but one phase of the whole; namely, to a study of the motor functions only of the resected stomach. Nearly all authors who have studied the activity of the stomach after resection point out the considerable change which takes place in its motor functions. Not only the form and the topographic relations of the stomach are changed, but a change is also to be observed in its tone. The stomach walls become more feeble and distended (Spath, Friedemann, Kirschner, Hertel and others) and food is promptly evacuated into the intestine. The removal of the pylorus and antrum results in insufficient maceration of the food in the remaining portion of the stomach ("restmagen"). Also, food is badly mixed together with the gastric juices, the secretion of which is rudely disturbed in consequence of the removal of the pyloric glands, as well as by the removal of the prepyloric part, the function of which is to act as "the main stimulator of the acid secretion" ("sauerwacker," of von Bergmann; "sauerfabrik," of Haberer).

Some authors (Neumann, Mirkin, and Morosova, Raix, Kuschnorenko and Hertel) are of the opinion that all these phenomena, especially the prompt evacuation on the part of the stomach remaining, may result quite independently of the method of the resection, *i.e.*, with regard to Billroth's methods I or II.

Other authors (Spath, Sauermont, Jansen, Beresov, Bal and others),

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on the contrary, have observed that the food, after a Billroth I resection, was retained in the stomach for a longer time. Bremer and Held offer the explanation, that the form of the stomach, resulting after resection by the Billroth I method, promotes, to a considerable degree, slower evacuation than the form of the stomach obtained when it has been resected by the Billroth No. II method. A Billroth I leaves a gastric stump, which being connected with the duodenum is located between two fixed points—the hiatus esophagus and the duodenum—that is, it is obliquely directed from the left upper point downwards to the right. On the other hand the stump of the stomach, resulting from employment of the Billroth II method, is connected with the mobile loop of the gut, which brings its axis into a vertical position in the upright posture. The latter group of authors mentioned, believe that such a vertical position of the gastric stump favors a quicker evacuation than the oblique position resulting from the Billroth I method.

The average normal evacuation time from the resected stomach, if it is in good condition clinically, lasts 20 minutes according to the observations of Rosenblat and Balaban; but Bremer and Held, Beresov and Stern, Goetze, Raiz and others, show that there may be such a shortening of this period that the evacuation may be accomplished almost immediately. Food entering the stomach is not retained in it at all, but at once falls through the stoma of the anastomosis. There then occurs the type of evacuation which Germans term "*sturzentleerung*."

A rapid evacuation is especially dangerous, because of the likelihood of the formation of peptic ulcers in the small intestine, especially in those cases where the stomach is not widely enough resected and where, consequently, a part of the antrum remains, thus retaining the possibility of acid gastric juice secretion (Goetze). Some authors (Beresov and Stern) believe that the absence of the pylorus must be followed by momentary evacuation; and that consequently every resection of the stomach should inevitably result in this. Other investigators ascribe such a type of evacuation either to the method of the operation or to technical errors. Most observers, nevertheless, have noted rhythmic evacuation after gastrectomy, quite independent of the operative procedure employed, and following either a Billroth I or II method (Kalmanovsky, Seneque and Marx, and others).

Thus, from a review of the literature, no definite conclusion can be drawn as to which of the two main methods of gastrectomy can best provide the rhythm of the gastric evacuation. Goetze considers that there are two opposing sets of forces involved—the evacuating forces and the retaining ones. The former include the systole of the stomach and the hydrostatic pressure of the food itself, which is measured by the height of the liquid level in the stomach, measured from the exit. The opposing forces are the anastomosis and the hydrostatic pressure, the so-called "*hubhohe*" (which is measured by the height from the lower pole of the stomach to the level of the anastomosis).

The systole of the stomach depends on the musculature of the gastric wall,

the muscular fibers of which are constantly in a state of definite contraction, *i.e.*, the tone. The expansion of the stomach on the reception of food is a function of the tone. Goetze believes that filling-out of the portion of the stomach remaining after gastrectomy progresses in the same manner as the filling-out of the corresponding part in an unresected stomach. Goecke, Schuller, Seneque and Marx consider, too, that stomach tone does not suffer any change after resection, but remains the same as before. On fluoroscopy, the air-bubble is to be seen just as well as in the normal, unoperated stomach; and the contrast medium just as in a healthy stomach, smooths it out.

In addition to the tone of the resected stomach, the peristalsis plays a great part in its evacuation. Many authors think that peristalsis is not always observed after gastrectomy, and even not at once after the operation. Held observed peristalsis in a few cases and then only in the form of shallow, superficial waves. Goetze noted it only during the first two or three weeks following the operation; later on, it was absent, from which he inferred that the stoma at the anastomosis had become strictured. Fedorov, also, points out the lessening of peristalsis after gastrectomy. Seneque and Marx, owing to the absence of the antrum-pyloric segment following gastrectomy, deny even the possibility of peristalsis. Among eight patients in whom peristalsis was observed, six showed stenosis of the stoma of the anastomosis, the result of a recurrent cancer. These authors also believe that whenever peristalsis is observed after gastrectomy, obstruction of the exit from the stomach should be ascribed as the reason. Desmarest is of the same opinion.

Meyer-Burgdorf, and Hertel, observed that gastric peristalsis after the resection is independent of the method of operation. Contrary to their opinion, Rosenblat attributes the onset of peristalsis in the resected stomach to the operative procedure employed. Using the Billroth I method, he observed peristalsis in 78 per cent of his cases; while using the Billroth II method, it occurred in only 39.4 per cent. Hence, he concludes that it seems that the peristalsis following gastrectomy is the result of the restoration of reflex relations between the duodenum and the gastric wall.

The rôle of hydrostatic pressure, as a force assisting evacuation from the resected stomach, is chiefly emphasized by Goetze, Spath, Kelling, Mirkin and Morosowa, and Held. The motion of the diaphragm during the act of breathing plays, too, a certain part among the forces contributing to stomach evacuation. This is especially evident from the observations of Bremer and Held upon the stomach, resected by the Billroth I method. Here the remaining portion of the stomach (*restmagen*) is strained along its lesser curvature between the hiatus esophagus and the duodenum. In consequence of this, motions of the diaphragm, by pressure, considerably assist evacuation from the stomach. But this may be observed only during the first days following operation and, even then, only just after the beginning of a meal. From five to 10 minutes later, under the influence of the food, the stomach takes on the shape of an egg, its lesser curvature becomes more relaxed and, consequently

the diaphragm, during breathing, does not produce the previous influence upon evacuation.

Among forces delaying evacuation, the main force is the so-called "play of the pylorus" in the healthy, unoperated stomach. In the resected stomach, this phenomenon is replaced by the anastomosis, though Goetze believes that the latter does not possess the ability to close the entrance from the stomach. Opposed to his opinion, a group of authors consider that the muscular elements of the stomach form some kind of sphincter around the stoma of the anastomosis, which resembles the pylorus in its function. These authors observed such a sphincteric action only after resection by the Billroth I method (Spath, Rosenblat and Balaban, Hertel, Mirkin and Morosova, Wölfler, Maresch, Mayer and Schmidt).

At the Twelfth Congress of German Surgeons, Wölfler demonstrated the stomach of a patient five years after a gastrectomy performed by the Billroth I method. In the region of the anastomosis, he found a fold of mucosa having a height of 3.5 Mm., with a thickening of the muscular layer under it. Beresov and Stern ascribe special value to the modification of the Billroth I method developed by Haberer, according to which the gastric wall is sewed up to the duodenum, being tied with sutures in the shape of flounces. With this, in the region of the anastomosis, they found a thickened muscular layer, resembling somewhat a pyloric sphincter. They are of the opinion that the rhythm of evacuation practically depends upon the muscular contractions around this anastomosis. These contractions do not possess such a regular rhythm as does the pylorus, but later on the sphincter appears to acquire the same rhythm.

Experimentally, Bal, after performing a resection of the stomach by the Billroth I method, with the Haberer modification, also noted a thickening of the muscular wall in the region of the anastomosis. Finsterer, too, attaches great significance to the shape of the anastomosis, in regard to evacuation from the remaining stomach following gastrectomy. He offers his own technic for this operation, in which he makes an anastomosis with an incision in the lowest part of the stomach, while the upper part of the gastric stump, with the adjacent loop of a small bowel, he inverts into the stomach by means of the purse-string suture, thus forming a kind of valve over the anastomosis.

Some authors have observed, on fluoroscopy, not only a filling-out of the efferent loop, but the presence of the contrast medium in the afferent loop as well. Schwartz, Ogloblin, Kelling, and Schemacher consider this phenomenon as having a positive value, while Notzel and Teschendorf judge the retrograde filling of the afferent loop as a tendency of the organism to direct food along the normal unviolated channel. Beresov and Ribinsky observed, during the retrograde filling of the afferent loop, that there followed a heavy feeling and bilious eructations. Finsterer, fearing that in this case the duodenal stump might be insufficient, recommends the fixation of the afferent loop to the upper part of the gastric stump, thus forming an artificial spur. He considers that this will prevent passage of the food into the afferent loop.

MOTOR FUNCTION AFTER GASTRECTOMY

MOTOR FUNCTIONS OF THE STOMACH AFTER RESECTION

Based Upon Personal Clinical and Roentgenologic Observations

The appended observations were carried out under the supervision of Prof. L. W. Ratner, and cover a period of six years (1930-1936). Seventy-four patients were examined, who, during this period, had been subjected to gastrectomy for various conditions (Table I).

TABLE I
DISTRIBUTION ACCORDING TO DIAGNOSIS

Diagnosis	No. of Cases
Cancer of the antrum.....	9
Cancer of the body of the stomach.....	12
Ulcer of the antrum.....	6
Pyloric ulcer.....	4
Ulcer on the lesser curvature in the region of the angle.....	18
Ulcer on the lesser curvature above the angle.....	14
Duodenal ulcer.....	2
Peptic ulcer.....	8
Gunshot wound of the stomach *	1
Total.....	74

* The patient with the gunshot wound was operated upon in Berlin 18 years ago, but for the last two years has been under our observation.

According to sex, there were 55 males and 19 females. Distribution according to age groups is given in Table II.

TABLE II
DISTRIBUTION ACCORDING TO AGE GROUPS

Age Group	No. of Patients
From 20 to 30 years.....	10
From 30 to 40 years.....	31
From 40 to 50 years.....	18
From 50 to 60 years.....	13
From 60 to 70 years.....	2

The greater number of patients (67) were operated upon by the Billroth II method with the Hacker-Eiselsberg modification; of the remaining seven cases, five were operated upon by the classic Billroth II method, and two cases, by the Pólya-Reichel modification of the Billroth II method. Ten subtotal resections were performed.

The routine technic employed in the operation by the Billroth II method, with the Hacker-Eiselsberg modification, was as follows*: The vessels of the

* The operation described, designated as the Billroth II method, with the Hacker-Eiselsberg modification, may be found described in "Chirurgische Operationslehre," V. Kleinschmidt. Published in 1927. Some authors ascribe the operation to Hoffmeister-Finsterer, or to Krönlein-Mikulicz.

gastrocolic and gastrohepatic omenta were tied and the stomach freed from adhesions. A clamp was then placed upon the duodenum just beyond the pylorus, and another applied 2 cm. distal to it. (For the past two years, for this purpose we have used the Shulman's duodenal clamp.) The duodenum was cut between these two clamps. The gastric stump, wrapped in gauze, was turned to the left, while the duodenal stump was sewed in two layers, using a continuous catgut suture for the mucosa and a knotted silk suture for the seromuscular coat. A cut piece of omentum was sutured over the stump. A clamp was then placed upon the stomach, in the direction from the lesser to the greater curvature, in such a way that the lesser curvature was caught up as far as possible above the angle. A second clamp was applied distal to it. Between them, with a continuous suture, at a distance of from 6 to 8 cm., there was sewed up a loop of the small intestine nearest to the flexura duodenojejunalis, passing the loop through a hole in the mesentery of the transverse colon, beginning from the greater curvature. Above this suture, below the first clamp, the part of the stomach to be resected was cut out, and the sewed up loop of the small intestine was opened along its axis. Upon the gastric and intestinal mucosa there was placed a continuous catgut suture, that passed over the mucosa of the upper part of the stomach. The second line of sutures was placed upon the seromuscular coat of the stomach in its upper part, and on that of the stomach with the intestine in the region of the anastomosis. The gastric stump was sewed with separate sutures, up to the opening in the mesocolon. In four cases the operation was performed using the Petrov-Veresachinsky modification of the method.

Before operation every patient underwent the following examinations:

- (1) Gastric analysis.
- (2) Fecal analysis for occult blood.
- (3) General analyses of blood and urine.
- (4) Fluoroscopy of the stomach, in which special attention was paid to the motor functions. The shape of the stomach, its mobility, tone, peristalsis and evacuation were studied. In later years attention was also given to the outlines of the gastric mucosa.

Postoperative observations using the same scheme of examination as before the operation were continued at intervals varying from two weeks to six years. In carrying out radioscopy, special attention was paid to the motor functions. The majority of the patients (38) were examined after operation from two to five times, giving a total of 132 radioscopy examinations of the stomach after resection (Table III).

Postoperative Complaints.—Out of 74 patients, only four (with symptoms of cancer recurrence, revealed on radioscopy) felt epigastric pressure and suffered from vomiting after a meal. One of them, following an operation that had been performed in Berlin 18 years previously, suffered during the last three years from constant pains, which increased after ingestion of food and were sometimes accompanied by vomiting. The remaining 69 patients considered themselves quite healthy.

TABLE III
FREQUENCY OF RADIOSCOPIC EXAMINATION

Period of Postoperative Examinations	Number of Observations	Operated Upon for Cancer
From 2 wks. to 1 mo.	22	3
From 1 mo. to 3 mos.	23	7
From 3 mos. to 6 mos.	18	6
From 6 mos. to 1 yr.	21	9
From 1 yr. to 2 yrs.	21	5
From 2 yrs. to 3 yrs.	17	5
From 3 yrs. to 4 yrs.	4	1
From 4 yrs. to 5 yrs.	4	1
More than 5 yrs.	2	1
 Totals.....	132	38

All patients observed their diet only during first month following the operation. If, during this time, they broke the diet, they suffered from a feeling of heaviness in the epigastrium, and occasionally vomited. But as soon as they returned to their diet, all these phenomena disappeared. With time, more and more broke their dietary regimen. In four or five months following the operation, 14 out of 18 traced patients were eating freely any sort of food; and in from six to 12 months, only one of 21 patients was still dieting. Still later, none of them dieted, some of them even consuming alcoholic beverages such as vodka or beer in excess, without troublesome aftermath, with the exception of one patient who complained of a feeling of weight in the epigastrium after drinking three or four glasses of beer. Three others suffered similar epigastric pressure after an abundant meal, if it had been eaten quickly. When food was eaten slowly they suffered no distress.

The above indicates the insufficient capacity of the resected stomach, which being quickly filled, evokes the phenomenon of the so-called "small stomach." Similar phenomena were pointed out by Meyer-Burgdorf, Finsterer, Haberer and others. Kelling and Schuller draw attention to the feeling of hunger that arises soon after a meal and forces the patient to eat more often. In our series, only one patient experienced a feeling of hunger within a two-hour period after ingesting food. The others took their food three or four times a day, and experienced a feeling of hunger in from four to five hours after the meal. The amount of food they took exerted little difference from that taken by a healthy person.

Biesenberged and Wieser explain complaints of the epigastric pressure after a meal, by the presence of a sinus in the gastric stump below the level of the anastomosis. They consider that in such a "sackenmagen," retention and the stagnation of food occur. In our cases we could observe the presence of such a sinus in six patients. In one patient, the sinus was at first insignificant in size, but gradually enlarged during filling-up with the contrast medium. None of the six above-mentioned patients experienced any disagreeable feeling after a meal, and all felt themselves quite healthy. Thus our data do not

confirm the opinion of Biesenberger and Wieser on the harmful influence of the "sachenmagen."

Shape of the Resected Stomach.—Tuluzakov and Golooshko believe that the shape of a resected stomach depends only upon the surgeon, and has nothing to do with its preoperative form. Opposed to this, Goetze considers that the resected stomach should present on radioscopy the shape of the whole stomach. In all our patients we found that the resected stomach took on the shape of a funnel, sometimes elongated, sometimes shortened. The axis of such a funnel was always directed vertically with reference to the anastomosis, either at the very apex of the funnel, or a little bit to the side of it. Seneque and Marx observed the same shape of the resected stomach by the Billroth II method.

Such a form of the resected stomach becomes easily understandable, if it is remembered that in performing the gastrectomy by the Billroth II method, when we cut off the resected part, we made, in accordance with our technic, the incision from the lesser toward the greater curvature from above the right side downwards to the left, the anastomosis being made at the lowest angle of the gastric wound. Both for cancer and for ulcer operations, we intentionally left the lesser curvature as little as possible, because our observations demonstrated that ulcers always recur upon the lesser curvature. Cancer recurrences, too, took place in the gastric stump along the lesser curvature. In addition, the form of the resected stomach is greatly influenced by the tone of gastric walls. Seneque and Marx are of the same opinion.

Volume of the Stomach.—The volume of the stomach varied considerably depending upon the size of its remaining part, on the constitution of the patient, and on the lapse of time since the operation. With all other conditions equal, the longer the lapse of time since the operation, the larger the volume of the resected stomach. During the first three months following the operation, only six patients out of 45 examined, had a stomach of average size. All the others revealed small stomachs high in the subcostal region, which were but little distended after the ingestion of a full portion of the contrast medium. After a lapse of time, the volume of the stomach increased; after a year or more we found the stomach to be of small size in only nine out of 47 patients. In all the others the lower border of the stomach had attained a depth of from 3 to 4 cm. above the unresected stomach, and in one case it even reached this level. In no case did we observe the border reaching lower than the previous level. A gradual enlargement of the resected stomach manifests itself as a rule; but the sizes and lapses of time for this enlargement to be effected differ. It is not always possible to determine the exact causes upon which depend the degree and rate of distension. There is no doubt that the tone, the general condition of the patient and the food burden of the stomach are responsible. We were never interested in this question, because we noticed no connection between the size of the resected stomach and the manner of its evacuation.

Stomach Tone.—As the tone of the stomach influences greatly its shape

before the operation, doubtless it cannot cease to be an influencing factor after the operation. This can be proved by the fact that where we observed a lessening tone in a considerable number of resected stomachs, these took on the shape of the elongated funnel; whereas, in those cases where the stomach was in a shape of a shorter and wider funnel, the tone was satisfactory and normal.

It might be thought that hypotonus of the stomach observed in some cases before the operation would remain the same after the gastrectomy. This is not true. Our observations have shown that lessened stomach tone gradually improves and becomes a satisfactory normal one after gastrectomy.

This chiefly concerns those cases where, before the operation, we had found an atonic or hypotonic stomach accompanied by pyloric stenosis in consequence of ulcer or cancer. By resecting the stomach and thus creating a free exit of food from it, we remove the cause that led to the gastric hypotonicity; namely, the stenosis, and give to the muscular fibers of the stomach the possibility to restore after a lapse of some time, sometimes very soon, its contractive ability.

Twenty-eight out of 45 patients, concerning whom exact radioscopic data of the stomach before the operation had been obtained, showed hypotonic or atonic stomachs. After gastrectomy, in periods of from two weeks to one month, in eight out of 16 patients still under observation, we still found an hypotonic stomach; in three months, only four out of 18 under observation still showed an hypotonic stomach; after six months, and later, we found no patient with atonic or hypotonic stomachs.

The recovery of tone by the resected stomach is well demonstrated by systematic observation of the same patient. We traced for a period from five to six years after gastrectomy, at various intervals, 22 patients who had hypotonic stomachs before operation. In seven cases the stomach was restored to normal tone in from one to three months and kept it during subsequent examinations. In six months only one case still showed an atonic stomach.

The tone of a normal or resected stomach, we determine by the manner of its contraction on the reception of the contrast medium, by the shape of the air-bubble, and by its shape as a whole. Hypotonus of the resected stomach is revealed when the first portion of the contrast medium, entering the stomach, takes on the form of a prolonged triangle, when the air-bubble becomes drawn out downwards, and when the stomach itself takes on the shape of an elongated funnel. On the other hand, in the case of a hypertonic stomach, the contrast medium while distending the stomach should be of a triangle shape, the lower end of which is near the right angle; and the air-bubble is flattened.

Peristalsis.—In only three cases out of 132 fluoroscopic examinations made on 74 patients did we fail to see gastric peristalsis. In all the other cases we have usually found a shallow or weak peristalsis along the greater curvature, and often along the lesser curvature as well. We never observed a deep and

pronounced peristalsis. Peristalsis could be seen very shortly after gastrectomy. Two weeks after resection the appearance of superficial, lax peristaltic waves could be noticed after the entrance of the contrast medium; at first along the greater curvature and then, sometimes, also along the lesser curvature.

These waves could be observed also in those patients in whom, during resection, the large branches of the vagus nerve had been cut. This is quite comprehensible, if we take into consideration that basically the peristalsis is an automatic gastric function directed principally by its own autonomous nerve centers which lie in the gastric wall itself. Seneque and Marx are of the same opinion.

Based on his observations that gastric peristalsis, following operation by the Billroth I method, is more often to be observed (in seven out of nine cases), than after the operation by the Billroth II method (in 13 out of 33 cases), Rosenblatt draws the conclusion that the method of operation influences considerably the peristalsis, and that the latter is evidently the result of a restoration of the nervous reflex connection between the duodenum and the gastric wall. The presence of the peristalsis in nearly all our cases (in 71 out of 74 cases), who were operated upon by some modification of the Billroth II method, disproves his suggestion. Likewise, our observations disprove the opinion of Seneque and Marx, who deny even the possibility of peristalsis in the resected stomach because of the lack of the antro-pyloric segment.

Peristalsis in a healthy, unoperated stomach is of great importance for evacuation, because its waves force the gastric contents toward the pylorus and farther on into the duodenum, meanwhile resulting in better mixing together of the food and gastric juices. Whether the peristalsis plays the same rôle for the resected stomach is a question still unsolved. At any rate, its presence at the time of food reception in the resected stomach already indicates its participation in the process of food evacuation from the stomach. The real part which the peristalsis plays in the motor functions of the resected stomach will become clearer on further analysis of the basic processes of gastric evacuation.

Evacuation in the Resected Stomach.—If Goetze's opinion is accepted, that the evacuation of any stomach is a resultant of the interplay of opposing forces, some leading to the evacuation and other retarding it, we may begin an analysis of how these forces react to bring about evacuation of the resected stomach. One of the main factors is the hydrostatic pressure of the food itself. It is greater, the higher the level of the liquid content in the stomach. From this point of view the hydrostatic pressure in the stomach after the operation by the Billroth II method is considerably higher than by that resected by the Billroth I method, because in the first case the axis of the stomach is directed vertically downwards and the anastomosis is situated at the lowest point of the gastric stump. To decrease this pressure, Goetze offered his modification of the operation. He made the anastomosis a little

higher up, thus leaving, from the lower end of a stump to the level of the anastomosis, a sinus of a certain size, thereby shaping the stomach into the form of a sack ("sackenmagen"). Goetze worked on the theory that the evacuation of such a stomach would be considerably delayed because of the decrease of the hydrostatic pressure due to the "*hubhöhe*." (The pressure of a column of liquid from the lowest point in the stump up to the level of the anastomosis.)

The tone of the resected stomach which, as we have seen above, gradually became normal in nearly all our patients, should be considered as the second factor assisting evacuation.

Finally, peristalsis is of extreme importance in emptying, but it is closely bound up with stomach tone. The feebler the tone, the less intensive are the peristaltic waves. The stomach with a normal tone possesses active peristalsis which is the more expressed, the more resistance the food meets with in its evacuation. To overcome the contraction of the pylorus during evacuation requires strong and deep peristaltic movement. The feebler the resistance offered by the pylorus during evacuation, the less the force required of the peristaltic wave for overcoming the resistance. Precisely such a condition obtains in the resected stomach in which there is usually observed a superficial lax, but never a deep segmenting peristalsis.* This possibly may be explained by the fact that the hydrostatic pressure of food together with a systole in the gastric wall, are practically sufficient in themselves to effect evacuation, and only a little additional force, expressed by a weak peristaltic movement, is required to overcome the impediment.

What is this impediment to evacuation from the resected stomach, and does it exist at all? Since in a healthy, unoperated stomach there exists such an impediment (and a very strong one), in a form of the pylorus with its powerful musculature, then there arises naturally the thought of the presence of an analogous regulative apparatus in the region of the anastomosis of the resected stomach. Some authors (Beresov, Bal and others) hold this opinion. They found evidence of muscular pressure around the anastomosis, which, as they presume, closes the anastomosis on contracting and opens it by relaxation, thereby letting through certain portions of the contrast meal. Nearly all authors, who call attention to the existence of this rhythmic evacuation in a resected stomach, made their observations only upon stomachs operated upon either by the Billroth I method, or by its Haberer's modification. This fact gave to Bremer and Held the idea that there is formed some new automatic reflex which acts by contracting the muscular layers of the anastomosis and by annular compression of the bulbous duodeni. They presume that the existence of such a reflex is quite possible, if there is taken into consideration

* We have never observed any considerable constriction of the anastomosis in the resected stomach; therefore, we cannot judge whether peristalsis of a segmenting type will arise analogously to that which takes place at the stenosis of the pylorus in the unoperated stomach.

the presence of a definite nerve plexus in the region of the stomach angle (Keith, Orator).

Our observations do not bear out the principal theses of these authors. First of all, it is not right to assume that the rhythmic evacuation, which made them infer the formation of a "quasi-pylorus," can be observed only after resection by the Billroth I method. Among our 74 patients, in only seven cases, have we seen a continuous evacuation of the stomach, and this only during the first six month after operation. The remaining 67 patients showed rhythmic evacuation in definite lapses of time and with definite portions of various volume. Complete evacuation of the resected stomach required from 15 minutes to 1 or 1½ hours, ranging mostly from ¾ to 1 hour. As already stated, all our patients were operated upon by the Billroth II method, usually accompanying it by its Hacker-Eiselsberg modification. Thus, taking into consideration the presence of a rhythmic evacuation after the operation by the Billroth I method (according to the data of Beresov, Bal, Bremer and Held, Goetze, and others), and that gained from our own observations, one has to draw the conclusion that the rhythmic type of evacuation is common to both methods. Seneque and Marx came to the same conclusions.

Beresov and Stern consider the Billroth I method, using the Haberer modification, as the one which creates the best conditions for obtaining rhythmic evacuation from which rose the impression of the formation of a "quasi-pylorus." Experimenting on dogs, Bal examined histologically this "quasi-pylorus," or, as he calls it, the "pap-roller." This "pap-roller" shows itself to be of a different structure in the more dense central part. In some cases it was formed by intrusion of a seromuscular layer of the stomach and duodenum into the thickness of the anastomosis. In other cases it was formed from the seromuscular layer of the stomach alone. In the third group of the Bal nomenclature, in which the "pap-rollers" very closely resemble the normal pylorus structure, they differ, nevertheless, microscopically by revealing a considerable growth of scar tissue in the submucous layer. This scar tissue is located over the muscular elevation in the shape of a large strip.

At the Twelfth Congress of German Surgeons, Wölfler demonstrated the stomach of a patient, five years after resection by the Billroth I method. On the border between the stomach and duodenum, in the region of the suture, there could be distinctly seen a fold of mucosa (3.5 Mm. high) with a thickening of the muscular layer under it.

It would seem that the existence of a thickening of the muscular layer, rising in the region of the anastomosis, is not a matter of doubt, because it is already formed during the operation by means of connecting the seromuscular and mucous layers of the stomach and duodenum (Billroth I method), or of the stomach and a loop of intestine (Billroth II method). But it can be questioned, whether this thickening of the muscular layer will act as a sphincter. There is required for a sphincter: First, the existence of a muscular apparatus able to function actively, that is, able to produce active contraction and relaxation of its fibers, now narrowing, now enlarging the

opening surrounded by them. Second, the presence of a nerve apparatus which influences the sphincter in a reflex way and which provides the rhythm in its work.

The pyloric sphincter consists of muscular fibers, mostly of the middle layer, which circularly clasp the pyloric opening, close it on contraction and open it on relaxation. Quite another condition is obtained in the region of an anastomosis after gastrectomy. As already noted, the muscular thickening in this region consists of a muscular layer of the stomach (using the Billroth I method). While separating the stomach from the duodenum, the latter is usually cut transversally. Therefore, it is permissible to assume that a bunch of circular muscular fibers of the intestine is caught into the suture. Quite another picture obtains when cutting the stomach wall. Here it is doubtful, that one can calculate the cut during the operation so as to include a bundle of circular fibers into the suture of the stomach. Operating by the Billroth II method, we do not meet with such a bundle of circular muscular fibers in the muscular layer of the intestine because, while making the anastomosis, these fibers are usually dissected transversally, due to the fact that the opening of the intestine is formed by incising it along a section of its axis.

Moreover, muscular fibers introduced into the suture usually are soon penetrated by scar connective tissue which destroys their contractile activity. The existence of pronounced scar tissue over the muscular rollers in the region of the anastomosis was observed also by Bal in his "pap-rollers." Our histologic examinations show that formation of a scar tissue over the muscular rollers, that is, outside of them, is not so pronounced as the penetration of the muscular fibers by scar tissue. Seneque and Marx, came to the same conclusion. They could get no proofs of muscular fiber regeneration during the regeneration of the gastro-intestinal tract wall, nor could they find any such arrangement of muscular fibers which might be called a sphincter.

(In the illustrations submitted of the histologic preparations of sections made from the region of anastomosis in two patients (six and three years, respectively, after operation), the arrangement of the two muscular fiber layers can be seen. The thicker layer is that of the stomach wall; the thinner, that of the intestinal wall. The high magnification reveals that the muscular fibers of the muscular walls are wholly penetrated by connective tissue elements (Figs. 1, 2, 3, 4). This penetration of muscular fibers by connective tissue elements is still more pronounced in the anastomosis of a dog's stomach, resected by the Billroth II method.)

The second condition required for a true sphincter, is the presence of a reflex, automatic apparatus which can regulate the work of the sphincter. The pyloric sphincter functions mostly under the influence of the so-called Hirsch-Mehring-Pavlov reflex which, though not being the only reflex controlling the function of the pylorus, nevertheless plays a prominent part. Many other agents influence the function of the pylorus, for example, the

mechanical irritation of the duodenal mucosa, reflexes on the part of other organs if they are pathologically involved (cholecystitis, cancer of esophagus) and probably many others. On removing the pylorus, this reflex bond is completely broken. Can the reestablishment of this bond after resection by the Billroth I method be expected, as suggested by Rosenblat? It is a matter of regret that the question of reflex bonds of the pylorus has not been studied enough in a healthy stomach. Therefore, it is difficult to contribute something definite to the question of the possibility of the reestablishment of these bonds after gastrectomy by the Billroth I method, or of the formation of a new automatic reflex, as suggested by Bremer and Held. Thus, there are no data, either anatomic or physiologic, which could be used to prove the existence and functioning of such a sphincter.

As regards operation by the Billroth II method, there can be no justification to consider the existence of a sphincter around the anastomosis, because, first of all, there is absent the principal element of a sphincter; namely, circular muscular fibers.

The fact of the presence of a zone of clarification observed in the region of the anastomosis on radioscopy of the resected stomach, creates the impression of the existence of a sphincter. These zones may be observed in individual cases after resection both by the Billroth I and II methods. We observed such zones of clarification in the region of anastomosis in seven of our patients. In some of them this phenomenon was systematically repeated at every roentgenologic examination at various intervals after the operation, ranging from three months to four or five years. In several cases, such a clarification "sphincter" was observed only during the first period after operation and then disappeared, and could not be duplicated on further radioscopy.

This lighter strip in the region of anastomosis, with the contrast medium passing through it, is judged by some investigators as a proof of the existence of a "sphincter." It seems to us that the presence of this zone of clarification is completely explained by the thickening in the region of the suture of the anastomosis, created by the doubling of the two walls; namely, the gastric wall and that of the intestine.

On the basis of the above, we feel justified in challenging the possibility of a sphincter or a "quasi-pylorus" (Beresov) formation in the region of the anastomosis after gastrectomy by the Billroth I or II methods. Nevertheless, the fact of a rhythmic type of evacuation of the stomach after its resection remains and has been proven by our observations, as well as by those of Schindler, Moutier, Hertel and Calius. This fact requires explanation. We consider that the change in resistance which at times permits the contrast medium to be periodically carried through the anastomosis, and at other times compels retention above it, may be explained by the contraction either of the loop of the lean intestine, adjacent to the stomach, or by that of the duodenum. Mehring, in 1897, at the 15th Congress of Therapeutists, on the basis of his work on duodenal fistula, carried out on the resected stom-

achs of dogs, reported that evacuation takes place neither faster nor slower than in the healthy stomach. It is accomplished at intervals, periodically under relatively great pressure, and the evacuation is regulated by the degree of filling the duodenum.

Cannon also points to the rhythmicity of contraction of the duodenum as the force restraining evacuation from the resected stomach and compensating for the contraction of the pylorus. Kocher considers that any contraction of the loop of intestine below the anastomosis can restrain evacuation. Hertel, Birgfeld, Kalmanovsky, Seneque and Marx are also of the same opinion. Schindler and Dagayev, likewise, emphasize the existence of definite relations between the functioning of the anastomosis and the condition of the intestine. Our observations confirm the correctness of this opinion.

On a radioscopy of one resected stomach we noticed a new detail concerning evacuation which we were able to confirm in nearly all subsequent cases (in 93 out of 132). After the first swallow of the contrast medium, the first part of the meal slides down at once without meeting any resistance through the anastomosis into the efferent loop. Then the remaining part, and the newly swallowed portions of the contrast medium, which for some time were kept detained over the anastomosis, began their rhythmic (though not always at equal intervals) evacuation by definite amounts through the anastomosis into the efferent loop.

Involuntarily, the thought arises that the first portion of the contrast medium, on its passage from the stomach through the anastomosis into the efferent loop, evokes by irritation of the mucosa such a peristaltic movement in the loop of the intestine which reacts to unlock the anastomosis after its period of closure. We know from physiology the so-called law of intestinal movement which states that the loop of intestine contracts over the bolus of food and dilates beyond it in such a manner that, having carried this bolus of food farther on, it contracts—during which the distal part of the intestine dilates. A contraction of the intestinal loop results from the contraction of a bundle of circular fibers, the so-called *stratum circulare*, which represent a rather stronger layer. If an anastomosis is effected either by the Hacker-Eiselsberg method or by any other modification of the Billroth II method (not including the Roux modification) the opening in the intestine is made by dissecting it along its axis. It follows that all circular muscular fibers are transversely cut. These, when contracting, will tend to result in a maximum drawing away of the edges of the opening, thus opening the anastomosis between the intestine and the stomach. The closing of the anastomosis will take place when this intestinal loop again becomes relaxed. Then the contraction of circular fibers will cease, together with the drawing away of the edges of the anastomosis. Simultaneously the fibers of the *stratum longitudinale* begin their contraction and bring the edges of the anastomosis still nearer together.

Such a type of evacuation which is regularly observed, practically on each radioscopy of the resected stomach, we consider as the normal type of

evacuation for a resected stomach. This opinion on the manner of evacuation of the stomach resected by the Billroth II method, I expressed in 1935, and it entirely coincides with the conception of Seneque and Marx, published in January, 1936. These observers as well as Bergeret and Caroli have met with the above described type of the evacuation from stomachs resected by the Billroth I, as well as by the Billroth II method.

It can be assumed that in a considerable number of the remaining 32 patients, examined earlier, who showed at the time of radioscopy only the presence of a rhythmic evacuation, the latter took place also in the manner which, from our point of view, is normal for the resected stomach.

Rhythmic evacuation does not always proceed in equal intervals of time. Cases were met with in which even, in the same patient, we observed unequal intervals between passage of two portions of the contrast medium through the stoma of the anastomosis, sometimes at longer and sometimes at shorter intervals. There were individual cases, where after passage of the first portion of a contrast medium through the stoma, there was observed a period lasting from two to three minutes, in which the stoma was closed followed by the usual rhythmic evacuation. Sometimes even the first portion of the contrast medium did not pass through the stoma, but remained above it for more or less long periods of time. Only a dose of an additional amount of the contrast medium, resulting in an increased hydrostatic pressure finally pushed it into the efferent loop by the help of active peristaltic movement.

We had nine such cases. This phenomenon becomes evident if there is taken into consideration that this was observed exclusively during the first period of time following the operation. In five patients we observed it in from two to three weeks after operation; in four, from one to two months, and only in one patient in six months post operation. In this period, the edges of the anastomosis as well as the wall of the adjacent intestinal loop are in a state of increased sensitiveness toward any irritation in consequence of the inflammatory edema of healing, hematoma, *etc.*

In some cases there may exist other reasons accounting for such a spastic contraction of the region of anastomosis after swallowing the first portion of a contrast medium. In patients who had undergone gastrectomy for cancer of the stomach, this type of evacuation presented the first symptoms of a cancer recurrence, still unrevealed by other radioscopy or clinical manifestations. Continued observation of these patients showed, indeed, the development of cancer recurrence in the region of a gastric stump. We consider our hypothesis quite acceptable, because cancer in the region of any natural apertures, such as cardia, pylorus, the urinary bladder neck, *etc.*, is usually accompanied with a secondary spasm of the adjacent musculature.

The Efferent and Afferent Loops of the Intestine After Gastrectomy.—Rhythmic evacuation of the resected stomach plays an enormous part in the whole further process of digestion. It is impossible in the present article to discuss in detail questions of the chemistry of digestion after gastrectomy. We may call attention only to the fact that albumins and fats were not reacted

on chemically during their stay in the gastric stump. Pepsin digestion is absolutely absent, while trypsin enters the stomach through the stoma of the anastomosis only in traces, and even this not always. Chemical treatment of the food begins from the moment the food leaves the stomach, to come into contact with the duodenal juices in the efferent loop. The mixing together of food and duodenal juice will be more complete if food enters the efferent loop not as a continuous stream, but rhythmically and in definite portions, such as we had met with in all our observations. The mixing together of food with the duodenal juices takes place, first, in the part of the efferent loop nearest to the anastomosis. This segment gradually dilates, reaching in some cases to rather considerable dimensions and forms the so-called "*nachmagen*." In the "*nachmagen*," food is retained for some time (from $\frac{1}{2}$ to 1 minute), undergoing agitating movements; then it is evacuated farther along to the efferent loop. Such a "*nachmagen*" we could observe in 21 cases; and in 15 cases it appeared only in six months after the operation. In no case did we observe the "*nachmagen*" earlier than in one month after operation. By their function the segments of the efferent loop nearest to the anastomosis are closely related to the resected stomach; this fact made Seneque and Marx assimilate them into one "*gastro-intestinal block*."

The segments of the efferent loop nearest to the anastomosis are more subject to the constant influence of little changed food than all the other small bowel. In consequence of this its mucosa suffers a considerable change: The Kerering folds become thicker, sometimes taking on a loop-like character.

These observations force us to establish, at least radioscopically, the development of chronic catarrhal inflammation of the mucosa in the efferent loop (*jejunitis chronica*). True, these catarrhs in some cases disappear, as we observed in five cases; but for the most part they remain for years, though not always accompanied by any clinical manifestations. The afferent loop rather often became filled with the contrast medium (in 37 out of 132 cases, *e.g.*, in 28 per cent of the cases), but only at its beginning. In two cases the filling extended a rather considerable distance, and in two other cases it even reached the bulbous duodeni. In these cases, the contrast medium was returned back into the stomach by peristaltic movements after a short time. When the contrast medium entered only the initial part of the afferent loop, it was returned almost instantly into the stomach.

The Gastric Mucosa After Resection.—The data furnished by Meyer-Burgdorf, Henning, Wanke, Haberer, Konjetzny, Redwitz and others, suggest that the presence of a rough, changing aspect of the gastric mucosa is one of the causes of dyspeptic troubles. Konjetzny, Puhl, Chiari, on microscopic examination of the resected stomach wall, found reddening, edema of the mucosa, and enlarged lymph nodes. The microscopic examination by these authors revealed changes corresponding to acute as well as subacute and chronic inflammatory processes such as degeneration of epithelial cells, fibrous leukocytic exudation in the intercellular space, connective tissue in the muscular layer and submucosa, and hyperemia and inflammatory edema up

to the muscular layer. All these manifestations developed independently of the presence or absence of gastritis before the operation and, therefore, should be considered as secondary processes connected with the changed processes of digestion in the resected stomach.

Opposed to this, Bremer and Held discovered no secondary gastritis in the resected stomach. They explain the presence of thickened folds by swelling of the mucosa in consequence of limitations to the lymph stream after dissection of a large number of longitudinal lymphatic paths.

Out of 132 observations, we gathered data on the aspects of the gastric mucosa in 112 cases. Only in 22 cases (19.6 per cent) the folds of the mucosa were not thickened and showed normal direction. All persons examined were quite healthy. The same aspect of mucosa was found in these patients only in from one and one-half to two or three years following the operation. Examination of the same patients sooner after the operation (within six months or one year) invariably revealed pronounced thickening of the mucosal folds showing anomalous direction, sometimes presenting a loop-like aspect. In the remaining 90 cases we observed a considerably changed aspect of the gastric mucosa; its folds were thickened and their course anomalous, especially soon after the operation. Later on, in most cases, the folds took on a more normal direction, but still remained thicker. Only three of these patients felt pressure after taking coarse food or after an abundant meal. All others suffered no discomfort, such as heart-burn, belching, or epigastric pressure. They fed themselves on their customary food without observing the diet.

Such a complete absence of complaints on the part of patients after gastrectomy in spite of fluoroscopic evidence of changes ascribable to the chronic gastritis, might lead to the conclusion that gastritis finds its place after resection, and to the acceptance of the point of view of Bremer and Held.

But the difficulty of recognition of chronic gastritis lies in the fact that the signs which "doubtless characterize a disease; namely, the pathologo-anatomic changes of mucosa, do not always coincide with those symptoms by which a disease is usually named by a doctor or a patient" (Lurya). The above described macroscopic and microscopic evidence obtained by us and by other investigators on examination of the gastric wall, the fact of the presence of a changed relief in the gastric mucosa in the overwhelming number of our cases—all point to the existence of chronic inflammation in the resected stomach mucosa.

Our histologic examinations both of the gastric wall in a patient in four and one-half months since resection, and of the gastric wall after resection in a dog, confirm the presence of considerable changes of an inflammatory type.

All this compels us to share the opinion of those who maintain the presence of a chronic gastritis in the resected stomach. All conditions are present for the development of such a gastritis. Frequent disturbances in the order and type of a food reception are doubtless predisposing factors to the formation of a chronic irritative gastritis in an unoperated stomach. Such predis-

posing conditions include the reception of badly masticated food in consequence of the lack of teeth, as well as the hasty ingestion of it. The resected stomach mucosa in consequence of the lack of the antrum, diminished peristalsis, and the small dimensions of the stomach should react still more definitely to such chronic disturbances. Even if there is omitted from consideration the debatable questions concerning the influence of the lack of hydrochloric acid and pepsin, or the influence or presence of the duodenal and intestinal juices in the stomach, all other conditions being equal there are more chances for development of gastritis in the resected stomach than in the normal one. Chronic gastritis in an unoperated stomach is often developed without any clinical symptoms or with very insignificant ones. The

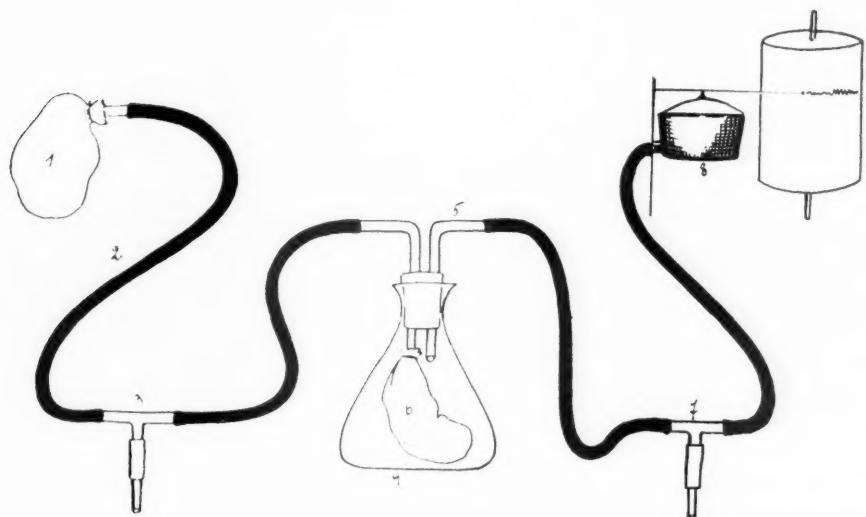


FIG. 1.—Schematic representation of the apparatus used for registering the contraction curves in the region of the anastomosis.

same fact is met with in the resected stomach. In many cases observed by us (109), this chronic gastritis was quite symptomless. In some cases patients considered themselves to be quite healthy, paying no attention to slight epigastric pressure after the reception of abundant food, or after a hastily consumed meal, because these phenomena disappeared quickly and did not manifest themselves after slow eating or on the reception of food in small quantities. Only in rare cases (eight patients in our series) were these feelings more constant.

Motor Function in the Resected Stomach on the Basis of Experimental Data.—Our own clinical and roentgenologic observations on the motor function in the resected stomach showed that gastric evacuation through the anastomosis occurs, as a rule, rhythmically in definite lapses of time. Considering the possibility of the formation of a new sphincter in the region of anastomosis to be a very doubtful one, and taking into account the literature, as well as the data of our own (unfortunately too few) microscopic examinations, I

believe that the periodical closing and opening up again of the anastomosis represents a complicated process which can be best explained by the contractive activity of the gastric walls themselves taken with, but subordinated in importance to peristaltic movements of the loop of intestine sewed to the gastric stump.

Assuming that the peristalsis of the sewed up loop of intestine takes place in a reflex way, in consequence of irritation to its mucosa by a portion of the contrast medium passing through the anastomosis, I decided to check this

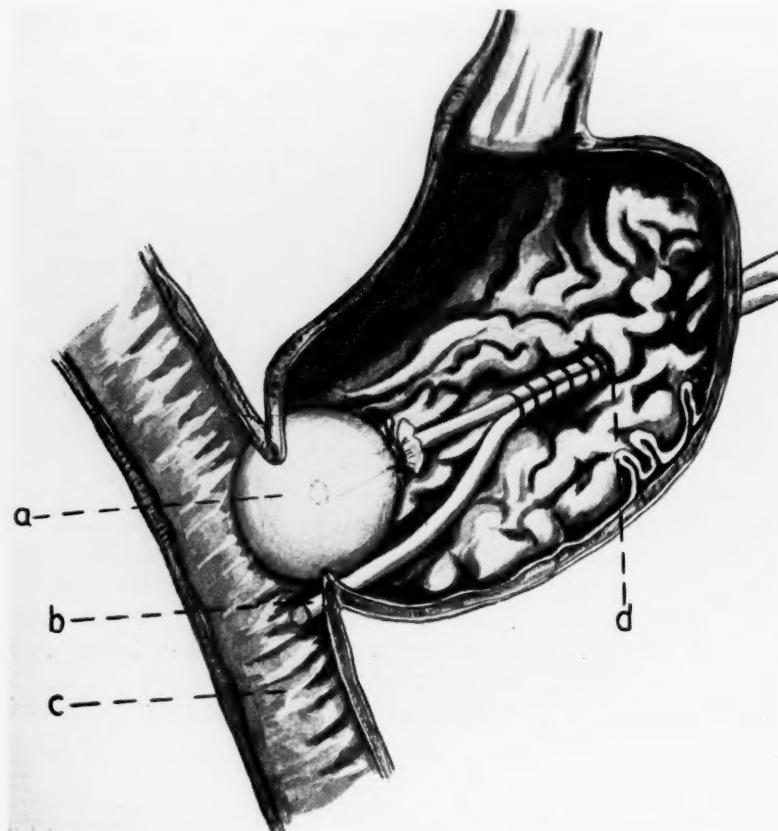


FIG. 2.—Schematic representation of a resected dog's stomach with a balloon introduced into the stoma of the anastomosis. (a) Rubber balloon (1 in Fig. 12). (b) Rubber tube through which Ringer's solution is introduced into the outgoing part of the loop. (c) The intestinal loop. (d) Stomach fistula.

suggestion experimentally on a dog using Danielopolu's method. The contractions of the gastric walls, or of the anastomosis, are transmitted by a thin rubber balloon to a Marey capsule and registered with a kymograph. For this purpose at the end of a thick-walled rubber tube (0.5 cm. diam.) we fixed a small rubber balloon. This rubber tube was connected by a tee with a damper consisting of a small flask provided with a tight fitting cork, through which passes a short tube, ending just under the cork, and a long tube to the opposite end of which is fixed a small rubber balloon. The short glass tube

of the damper through a second tee is connected with the Marey capsule, the needle of which, touching the kymograph, makes the necessary records.

By blowing air through the tee we distend the rubber balloon at the end of the rubber tube, simultaneously distending the rubber balloon in the damper. The air space remaining in the latter is connected with the kymograph with the tube. Vibration of the balloon transmitted to the balloon is recorded upon the kymograph, resulting in a definite curve.

Gastrectomy was performed upon a dog by the Hacker-Eiselsberg method. Three and one-half months later a gastric fistula was made in the same dog through which, under finger control, the thin rubber balloon was introduced

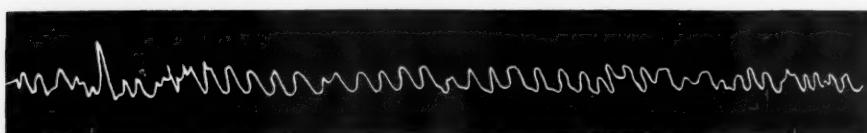


FIG. 3.—Gastrogram No. 1.

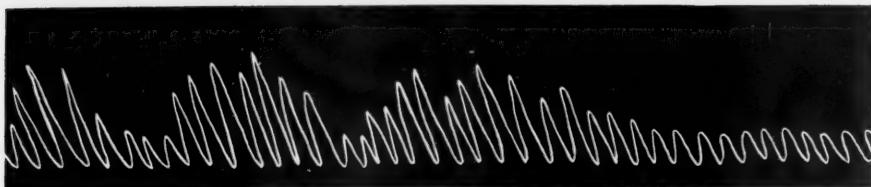


FIG. 4.—Gastrogram No. 2.



FIG. 5.—Gastrogram No. 3.

and fixed in the lumen of the anastomosis. In the state of rest, or in the absence of irritation of mucosa of the efferent loop or stomach, the region of anastomosis showed the absolute absence of contractions on the kymograph.

Zigzags of the curve reflecting the breathing movements of the diaphragm follow each other showing nearly no change in their amplitude or type.

On irritating the efferent loop mucosa with Ringer's solution, we observe that after some lapse of time, the anastomosis closes and then opens again. The corresponding gastrographic curve rises and falls, giving rise to a typical wave. In the same way a second wave is formed, having lesser amplitude, then a third wave, and so on. On irritation of the intestinal mucosa we create its peristalsis in the region of irritation. Thus peristaltic contraction of the intestinal loop, adjacent to the stomach, evokes the opening of the anastomosis, while its relaxation produces a corresponding closing. This

is seen from the gastrograms Nos. 1, 2, and 3. Intestinal peristalsis evoked by irritation of its mucosa does not cease at once with the elimination of irritation, but lasts for a certain length of time, gradually abating.

Corresponding to this, the gastrographic curve shows the more remote waves with lesser and lesser amplitude.

By irritation of the mucosa only of the stomach (as in experiment 3), there is obtained another type of curve illustrated by gastrogram, which shows atypical waves of very low amplitude, and these waves do not alternate with each other so regularly as in the former gastrograms. This might be construed to mean that the muscular wall of the gastric stump on irritation of its mucosa also participates in the closing and opening again of the anastomosis, but this participation is a very insignificant one.

CONCLUSIONS

(1) As a rule, the stomach resected by the Billroth II method shows a rhythmic evacuation. This type of evacuation is observed both on resection by the classic method of Billroth II or by its Hacker-Eiselsberg or Kronlein-Reichel modifications.

(2) In order to obtain rhythmic evacuation from a stomach resected by the Billroth II method, there is no need to complicate this operation by further modifications *e.g.*, the operation by Finsterer, Bal, Goetze and others.

(3) The type of evacuation obtained does not depend upon the extent of the resected region; the rhythmicity of evacuation is observed on subtotal gastrectomy.

(4) There is no difference in the type of evacuation obtained in stomachs resected by the Billroth I and or by Billroth II method.

(5) At present there are no data which would substantiate the belief in the formation of a sphincter in the anastomosis region after gastrectomy. Following resection by the Billroth II method, we consider such a formation to be quite impossible.

(6) The periodic closing and opening again of the anastomosis are explained in the main by peristaltic contractions and distensions of the efferent intestinal loop nearest to the anastomosis.

(7) Gastric tone after a partial gastrectomy becomes normal in time; a hypotonic or atonic stomach becomes normal in tone.

(8) Spasms of the anastomosis after gastrectomy undertaken for cancer present an early symptom of a recurrence of the cancer in the region of anastomosis.

(9) After gastrectomy, most patients exhibit hyperplastic gastritis, though without any subjective manifestations.

(10) After gastrectomy, chronic jejunitis follows, also without clinical manifestations.

(11) Normal evacuation of the stomach, resected by the Billroth II method, or by its Hacker-Eiselsberg modification, is in complete accord with their general condition of good health which gradually improves with the passing years.

SUBPARIELTAL RUPTURE OF THE INTESTINE DUE TO MUSCULAR EFFORT

REPORT OF TWO CASES

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THE subject of subparietal rupture of the intestine due to muscular effort was recently reviewed by Wilensky and Kaufman.¹ After a careful search of the literature the authors accepted 42 cases as genuine examples of this condition and added one case of their own.

Direct injury to the underlying intestine as a result of a penetrating wound of the abdominal wall is so frequent as to occasion no comment. It has also been long recognized that the intestine may be ruptured notwithstanding the presence of an intact abdominal wall. This injury may be of the bursting type, as in cases where air is forced under pressure into the rectum and sigmoid colon, or the tearing or crushing type seen where there has been some sudden blunt force applied to the abdominal wall. Excluding the foregoing types of intestinal injury there remain those cases, reviewed by Wilensky and Kaufman, in which muscular effort alone was apparently the cause of the intestinal rupture. Various theories have been advanced to explain how this could happen. According to the theory of Bunge,² as later modified by Haim,³ contraction of the abdominal muscles and diaphragm in severe muscular effort compresses the bowel and causes an elevation of pressure within the intestinal lumen. This rise in pressure is transmitted equally to all parts of the bowel and abdominal wall under normal conditions. If there is a point of weakness in the abdominal parietes, for example at the inguinal rings, the bowel wall will be unprotected in this place, permitting a bursting type of rupture of the bowel to occur. In support of this theory, Wilensky and Kaufman point to the fact that hernia was present in 33 of the 43 cases which they reviewed.

The subject of subparietal rupture of the intestine due to muscular effort also has definite medicolegal importance. If the muscular effort is in the course of employment, whether hernia is present or not, the resulting disability should be compensable. In the case of Wilensky and Kaufman and that of Wiedhopf,⁴ compensation was granted, as it was in the second case reported herewith.

CASE REPORTS

Case 1 (S.F.M.).—G. C., white, male, age 49, was admitted to the Ellis Hospital, November 3, 1933, with a history of having been working on a platform which was part way up a runway leading to the top of some concrete forms. His task was to guide the wheelbarrows pushed by co-workers around the curve on the platform and give them a push to start them up the second runway. The second runway was about 16 feet long

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and the loaded wheelbarrow weighed about 150 pounds. After he had been working for a few minutes at this job he was suddenly seized with abdominal pain and fell to his knees. He was immediately taken to the hospital.

Physical Examination.—The patient was examined one hour and a half after the onset of his illness. He denied previous abdominal trouble or indigestion. Examination disclosed a well developed and nourished man of powerful physique. The abdominal muscles were in a state of board-like rigidity and there was marked abdominal tenderness throughout. Temperature 100.4° F.; pulse 115; blood pressure 145/85. *Diagnosis:* Perforated peptic ulcer.

Operation.—Immediate celiotomy under spinal anesthesia was performed, through a right rectus incision. The peritoneal surfaces and omentum were found to be injected. The peritoneal cavity contained a considerable quantity of grayish-yellow fluid in which were strands and particles of what appeared to be partly digested food. Examination of the stomach, duodenum, gallbladder, appendix and region of the pancreas disclosed no abnormalities. It was then discovered that the fluid was escaping from a perforation in the jejunum. The perforated loop was located in the left upper abdominal quadrant. The perforation was 1.5 cm. in diameter and seemed to be about opposite the mesenteric attachment. There was no induration or scarring around or adjacent to it and the mucosa everted or pouted out around the margin. The perforation was closed in the long axis of the intestine, using two layers of continuous fine linen suture. The fluid was sucked and sponged out. The abdomen was closed without drainage. Smear of the fluid disclosed the presence of occasional red cells and a rare gram-negative coccus. *Staphylococcus* was reported on culture.

Postoperative Course.—During the first 24 hours after operation the condition of the patient remained satisfactory, the pulse being about 100, temperature 104° F. On the second day his condition became rapidly worse. The urinary output decreased and the urea nitrogen was found to be 88 mg. per 100 cc. In spite of intravenous administration of saline and glucose, the patient expired on the second postoperative day.

Autopsy (Dr. Kellert).—This was limited to an examination through the operative incision. When the abdomen was opened considerable brownish-yellow fluid mingled with greenish-yellow flocculi escaped. The peritoneal surfaces were everywhere covered with grayish-yellow, fibrinous, plastic exudate, particularly in the pelvis and epigastric regions. The appendix, mesenteric lymph nodes, pancreas, gallbladder, bile ducts and liver were normal. The spleen was enlarged to twice the normal size. The stomach was markedly distended but otherwise not remarkable. The duodenum showed considerable injection of the mucosa but there was no evidence present of ulceration or inflammation. The jejunum was normal throughout except at one point near the middle portion where a small opening had been recently sutured. About this opening the mucosa was hemorrhagic but there was no inflammatory or ulcerative process visible. The opening was situated near the mesenteric border and did not leak. The ileum was normal. There was no enlargement or ulceration of Peyer's patches. The colon appeared normal except at the terminal portion where diverticuli were found. None of these was greater than 0.5 cm. in depth and there were no associated inflammatory changes. No foreign object was found in the intestine or peritoneal cavity. The kidneys and genitalia were normal.

Pathologic Examination.—*Microscopic:* Sections from various portions of the intestine showed changes limited to the serosa and adjoining musculature. On the serosa was found a thick layer of pus cells and fibrin and numerous particles of necrotic vegetable material. At the site of the rupture there were marked acute and subacute inflammatory changes and suture material *in situ*. The mucosa was intact and did not show inflammatory changes. The small arteries showed intimal thickening and hyaline change.

Case 2 (A. G.).—S. S., white, male, age 52, was admitted to the Ellis Hospital, January 7, 1938, with a history of having been engaged in moving carboys, one of which slipped, necessitating an extraordinary effort to prevent the vessel from falling. While

doing so he felt an immediate, severe pain in the right upper abdominal quadrant. He was not struck in the abdomen.

Physical Examination.—The patient was examined two hours after the onset of his illness. He was a well developed, poorly nourished man of asthenic habitus. He complained of severe abdominal pain. There was marked rigidity of the abdominal muscles with tenderness to palpation over the entire abdomen. Leukocyte count 15,000.

Operation.—Immediate celiotomy was performed under cyclopropane anesthesia. A para-umbilical, right rectus incision was made. The peritoneal cavity contained free fluid and particles resembling intestinal content. Multiple particles of plastic exudate were found on the serosa of various loops of the bowel. The omentum was edematous. A small perforation of the ileum was discovered through which gas bubbles and intestinal contents were escaping. The opening was closed in two layers, using a continuous silk suture. A stab wound through McBurney's point was made and a cigarette drain inserted. Another cigarette drain was placed into the pelvis through the lower angle of the primary incision.

Postoperative Course.—The patient made slow but satisfactory recovery. The temperature returned to normal on the sixteenth day. The patient was dismissed on the twenty-eighth day following operation and allowed to return to work after two months.

Comment.—In neither of the cases was an inguinal or other type of hernia found. In the first case none was found at autopsy, and strangulated hernia was ruled out before the operation. It is possible that areas of structural weakness of the abdominal wall, as suggested by Wilensky and Kaufman, were present. No careful search for such finding was made at the autopsy in the first case. In the second case the patient was carefully examined by a physician attached to the compensation court before he returned to work, who reported that no hernia was present. In both cases testimony was taken before the compensation court and it was clearly proven that there had been no trauma to the abdominal wall.

Medicolegal Aspect.—In Case 1, which terminated fatally, the widow, through her attorney, brought action in the local compensation court of the New York State Division of Workmen's Compensation against the employer to recover an award for her husband's death. There was considerable medical testimony given on both sides with the outcome depending upon the question of whether or not there was a preexisting ulcer present. The referee finally disallowed the claim after having the Chief Medical Adviser examine the evidence. The referee concluded that the exact cause of the perforation was not definitely shown but that the weight of medical evidence was to the effect that it was not due to accidental injury arising out of and in the course of employment. This verdict was appealed to the Board, where it was sustained. In Case 2, which terminated in recovery, before the same compensation board at a later date, award of compensation was given, there being no contest on the part of the carrier and no question as to the direct causal relationship between the man's employment and the perforation of the ileum.

Summary.—Two cases of subparietal rupture of the intestine due to muscular effort are submitted. In neither instance was there a blow or other injury of the abdominal wall and in neither was a hernia found. In one case compensation was awarded and in the other it was not.

Case 2 was a patient of Dr. Albert Grussner, Schenectady, New York, and acknowledgment is made of his kindness in allowing it to be reported herewith.

REFERENCES

- ¹ Wilensky, A. O., and Kaufman, P. A.: Subparietal Rupture of the Intestine Due to Muscular Effort. *ANNALS OF SURGERY*, **106**, 373-393, September, 1937.
- ² Bunge: Zur Pathogenese der subkutanen Darmrupturen. *Beitr. z. klin. Chir.*, **47**, 771, 1905.
- ³ Haim, F.: Beitrag zur Pathogenese der subkutanen Magen-Darmrupturen. *Arch. f. klin. Chir.*, **93**, 685, 1910.
- ⁴ Wiedhopf: Beitrag zur Pertungsruptur des Dünndarms ohne Bauchtrauma. *Zentralbl. f. Chir.*, **56**, 39, 1929.

THE USE OF SULFANILAMIDE IN THE TREATMENT OF PERITONITIS ASSOCIATED WITH APPENDICITIS

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THE MORTALITY of appendiceal peritonitis has not shown a general decline during recent years in spite of the numerous advances in pre- and postoperative care.^{1, 2, 3} In this clinic we have been able to show an improvement in mortality following the addition of sulfanilamide to the routine treatment of the severe cases of appendicitis. Although the series since the addition of sulfanilamide to the routine therapy has not been large and the data may not be statistically significant, we are convinced by the clinical evidence that sulfanilamide therapy subsequent to operation has ameliorated the severity of the reaction in spreading peritonitis in many cases and has saved some lives that otherwise would have been lost.

The value of sulfanilamide in hemolytic *Streptococcus* infections was first determined in the peritoneum of the mouse,⁴ and its effectiveness in patients was first demonstrated by Colebrook^{5, 6} in puerperal sepsis in which peritonitis is a common cause of death. The drug has probably not been employed extensively in other types of peritonitis because it was introduced as a specific therapeutic agent for hemolytic *Streptococcus* infections, though it has been used successfully in the treatment of colon bacillus infections of the urinary tract.

In the latter part of 1936, we began the use of sulfanilamide in spreading peritonitis associated with acute appendiceal infections and in those instances where it was feared that a spreading infection might develop.

Results.—It is a fortunate circumstance that two of the authors were concerned with the operations upon the patients in the earlier group and in large part on those in the sulfanilamide treated group. Surgical technic, anesthesia, and pre- and postoperative therapy were the same in both groups.

Shortly after starting the use of sulfanilamide postoperatively in the severe cases of appendicitis with peritonitis, death occurred in a patient operated upon for acute appendicitis. The infection in this patient was not severe at the time of operation and sulfanilamide was not begun until the third day after operation when the patient had evidences of a very widespread infection. At autopsy the spreading infection was found to be due to a blown-out stump.

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Since then, 250 consecutive cases of acute appendicitis have been operated upon on the service of the senior author at the Hospital of the University of Pennsylvania without a death from any cause.

Table I is a compilation of the mortality figures with acute appendicitis and its complications on the same service, from its inception. The diagnosis in these cases has rested on the findings of the surgical pathologist who examined the appendix grossly and microscopically, except in an occasional case of abscess in which the appendix was not removed.

TABLE I
THE MORTALITY FROM ACUTE APPENDICITIS AND ITS COMPLICATIONS
Service E, Hospital of the University of Pennsylvania

	Total Cases	Deaths	Drained Per Cent	Gross Mortality Per Cent
Before the use of sulfanilamide (to 1936)....	552	8*	37.0	1.4
With the use of sulfanilamide (1936 to May, 1939).....	257	1†	43.0	0.4
Total.....	809	9	38.0	1.1

* One death occurred in a patient not operated upon.

† This patient did not receive sulfanilamide until three days after operation.

The operations were performed by men who had completed their internships from two months to 20 years previously. In the earlier part of the series, the majority of the operations were performed by the chief of service. In the latter period the greater number were performed by surgical fellows.

Summaries of two case histories are given to illustrate the clinical course of very ill patients who were operated upon and then treated with sulfanilamide. Many other cases of widespread peritoneal infection could equally well be presented.

ILLUSTRATIVE CASE REPORTS

Case 1.—Hosp. No. 39563 (Surgical): J. G. F., white, male, age 50, was admitted to the Hospital of the University of Pennsylvania, June 23, 1938, complaining of severe generalized abdominal pain. Abdominal discomfort had begun two days previously, but it remained mild until the morning of the day of admission, when it rapidly increased in severity and pain was referred to the right shoulder.

At the time of admission there was widespread rigidity with accompanying tenderness and rebound tenderness. Peristalsis was suppressed. Rectal examination was negative except for prostatic hypertrophy. Temperature by rectum was 100.8° F., pulse 100, respirations 28. W.B.C. 14,000, hemoglobin 92 per cent.

Roentgenologic examination showed no air under the diaphragm. A diagnosis of ruptured peptic ulcer was made and celiotomy performed through an upper right rectus incision. The peritoneal cavity was filled with frank pus. Both surfaces of the liver were bathed with it. No perforation of the stomach or duodenum was found. The origin of the pus proved to be a ruptured appendix.

The appendix was removed and a drain was introduced through a stab wound in the right lower quadrant. As the wall of the cecum was necrotic, a rubber catheter was introduced and the cecum closed around it.

Sulfanilamide was administered hypodermically every six hours. The total dose was

6.4 Gm. the first 24 hours, 8 Gm. the second 24 hours, 6.4 Gm. the third 24 hours followed by 4.8 Gm. per day. After the fifth day oral administration was used with gradually diminishing doses. The drug was stopped on the eighth postoperative day. Recovery was complicated by a psychosis characterized by disorientation and hallucinations.

The highest temperature, 103.4° F. by rectum, was recorded shortly after operation. The temperature declined by lysis over a period of ten days. The pulse rate was compatible with the temperature at all times.

Case 2.—Hosp. No. 39401 (Surgical): J. R., white, male, age 25, was admitted to the Hospital of the University of Pennsylvania, June 4, 1938, complaining of abdominal pain. The patient had had his first symptoms, nausea and vomiting, May 31, 1938. The following day he complained of abdominal pain. Localization of the pain occurred two days prior to admission and on the day of admission again became generalized.

At the time of admission the patient was evidently very ill. The abdomen was diffusely rigid and distended. Peristalsis was hardly audible. Shortly after admission the temperature was 104.2° F. by rectum, pulse 130. W.B.C. 17,400. Operation was performed under spinal anesthesia through a McBurney incision. Considerable purulent material was present without any evidence of localization and liquid feces were found about a perforated appendix. The appendix was removed and drainage instituted. Culture showed *Escherichia coli*, nonhemolytic *Streptococci* and *Clostridium welchii*.

Sulfanilamide was given by hypodermoclysis starting with a single dose of 4.0 Gm. The dose was 8.8 Gm. for the first 24 hours, 5.6 Gm. for the second 24 hours, and was then gradually reduced. The drug was stopped on the tenth postoperative day. The clinical chart showed a severe but subsiding reaction in a patient whose chances of survival seemed poor at the time of operation.

In order to afford a background for the results we have obtained, it is necessary to present certain statistical data regarding the series* and to outline the routine management employed. The age incidence of acute appendicitis in this series is shown in Chart 1. It is similar to that found by numerous others who have reported on the age incidence as observed in a general hospital.

Of the 780 cases 300, or 38.4 per cent, were drained. Peritonitis, mild to severe, localized or nonlocalized, was encountered in 355 patients (45.5 per cent). This apparently high incidence of peritoneal involvement is due to the fact that only patients in which the appendix, by histologic examination, showed acute diffuse suppurative appendicitis or more advanced disease have been included in this report. Gross perforation in the nonlocalized cases was demonstrated in 77 instances (9.9 per cent). Localized abscess was found in 51 patients (6.5 per cent).

Ileus, requiring enterostomy, occurred in nine patients. All of the enterostomies, except one, were performed prior to 1933, when the use of suction drainage as suggested by Wangensteen and Paine⁷ was begun. The exception was in a young boy with a hemolytic *Streptococcus* infection which invaded the retroperitoneal tissues and which was associated with an ileus of the adynamic type. Sulfanilamide would probably have saved his life.

The most common organisms cultured from the peritoneal exudate were, in order of their frequency: (1) *Escherichia coli*, and (2) *Streptococci*—

* The statistical analysis is based on 780 consecutive cases up to January 1, 1939. The mortality figures include the cases up to May 15, 1939.

hemolytic and nonhemolytic. Anaerobic cultures were not made in a large enough group of patients to be of statistical value.

Residual collections were drained in eight cases. It is interesting to record the fact that four of these occurred since beginning the use of sulfanilamide. It is possible that the drug favors local abscess formation but it is more likely that localization occurred in patients who before the use of sulfanilamide would have succumbed to a spreading peritoneal infection.

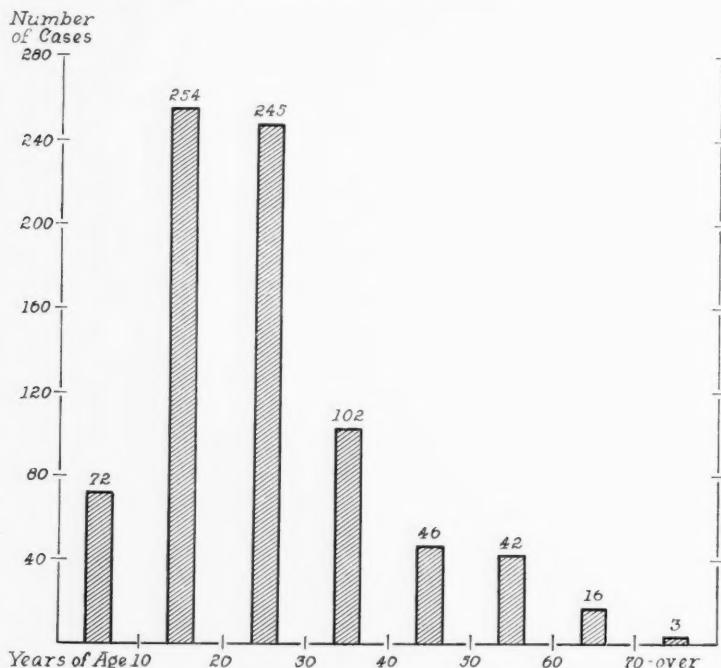


CHART 1.—Age incidence in acute appendicitis.
(Service E, Hospital of the University of Pennsylvania.)

Jaundice has been observed three times since beginning sulfanilamide therapy. In one patient this may have been due to hemolysis following the administration of the drug. In no instance did liver injury go on to abscess formation.

Routine Management.—Operation was carried out as soon as possible after admission to the hospital in all children, in all patients in whom pain started in the right lower quadrant, and in all other cases except for a few who arrived at the hospital late in the course of the disease in whom it was thought that localization of a peritonitis was occurring or that an abscess had formed. In the patients who presented signs of fulminating peritonitis the tendency has been more and more toward early operation (after one to two hours of the intravenous administration of a 5 per cent glucose and physiologic saline solution). Excepting clear-cut cases of appendiceal abscess which need not be regarded as emergencies, operation was delayed in less than 2 per cent of the cases.

Anesthesia.—In patients over 15 years of age, spinal anesthesia was employed wherever possible. A fall in blood pressure was averted in a majority of instances by the use of 50 mg. of ephedrine sulphate. Half of this amount was administered hypodermically about 20 minutes before operation and the remainder immediately before the spinal anesthetic was injected. In patients under 15 years of age, open drop ether was usually employed. In certain patients with marked hypertension or cardiac decompensation, local anesthesia was used.

Incision.—Whenever the diagnosis of acute appendicitis was made the McBurney incision was used. If it did not afford sufficient exposure, it was unhesitatingly extended in any desired direction.

Operative Procedure.—The appendix was removed regardless of its pathologic condition except in those instances where to do so would have destroyed the wall of a definite abscess and in one fatal case. Where an abscess was found against the lateral wall it was drained extraperitoneally whenever possible. The appendix was divided with the scalpel and the stump cauterized with phenol, ligated, and oversewed with linen.

Occasionally in patients in whom there was marked induration in the cecal wall, a rubber catheter was introduced through the stump and the cecum closed around it as advocated by Dorrance.⁸ We believe that it is of the greatest importance that the small bowel be kept out of the operative field except the terminal few inches of ileum. It was possible, as a rule, to do this through the McBurney incision and we believe that this is one advantage of this approach.

Drainage.—Fibroplastic exudate on surfaces other than the appendix itself, gross fecal contamination, and frank pus were regarded as sufficient indications for drainage. Free fluid was regarded as an indication only when it appeared to be definitely purulent. A few patients in whom the attachments of the appendix were extensive and fatty, and in whom numerous ligatures were necessary, were drained in the absence of other indications. As a rule the younger men drained some patients in order to be on the safe side, where men with more experience might not have done so.

When widespread peritonitis was present and the local exudate extensive, the appendiceal site was usually drained with iodoform packing covered with a sheet of rubber dam, the lateral colic gutter with a cigarette and the pelvis with a soft rubber tube or a cigarette and a tube. In such cases the wound was closed loosely. Hernia resulted in a certain percentage of such patients but we do not believe that this consideration should weigh in the surgeon's mind in planning the treatment of widespread peritonitis. The advantage of the gauze packing is that it prevents the small bowel from falling back into a heavily contaminated field. The object of drainage in the lateral colic gutter and in the pelvis is the prevention of secondary abscesses. The rubber dam covering the gauze is used to prevent adhesions to the gauze.

The principal objection to the use of drainage is the frequency of intestinal obstruction due to the development of adhesions. In this series, postoperative

obstruction necessitated ileostomy in eight cases up to 1933. In that year, suction drainage of the gastro-intestinal tract was instituted in all patients with extensive peritonitis with the result that only one ileostomy has been carried out since. This was due to paralytic ileus and not to adhesions. We believe that suction drainage of the gastro-intestinal tract has made a definite contribution to the treatment of appendicitis with peritonitis and that the argument that drainage of the peritoneum should be minimized on account of the danger of obstruction has lost most of its validity. The McBurney incision undoubtedly facilitates maintenance of the drains against the lateral wall.

Postoperative Management.—Confining the discussion to cases with moderate or widespread peritonitis, postoperative care was planned with a view to affording physiologic rest to the intra-abdominal viscera. Nothing was given by mouth or by rectum. Suction drainage was used prophylactically to decompress the upper gastro-intestinal tract. The use of prostigmine and pitressin was avoided if possible and these drugs were never resorted to during the first three days after operation. The only possible breach of the principle of putting the intestine at rest was the routine administration of morphine sulphate, which, according to the observations of Abbott and Pendergrass⁹ and of Puestow,¹⁰ may increase the motility of the small intestine. The use of morphine sulphate is defended on empiric grounds alone. Its value has been agreed upon by a number of clinicians of extensive experience. When given regularly and when suction therapy is also used, distention seldom appears. In elderly people the danger of respiratory depression must, of course, be weighed against the advantages offered by the use of morphine sulphate and a compromise reached.

Fluids were given intravenously by the continuous drip method. In all severe cases sulfanilamide was administered by hypodermoclysis. Substantial quantities of physiologic saline solution were needed for this and had to be reckoned in the total intake. The fluid given by vein contained 5 per cent glucose and usually half of it also contained 9.0 Gm. of sodium chloride per liter. In adults the total fluid intake was about 4,000 cc. the first 24 hours and about 3,000 cc. each succeeding 24 hours until the patient was clearly recovering. Serum chlorides and serum protein concentrations were determined every 48 to 72 hours and served as guides in the administration of saline.

Transfusions of citrated blood were often given in cases of anemia, hypo-proteinemia and in patients with rapid pulse rate and peripheral vasoconstriction.

Sulfanilamide Therapy.—Indications: Sulfanilamide is now being used in all cases that have been drained and in an occasional borderline case in which a rapidly advancing process has been found at operation but in which operation has been performed before the usual indications for drainage have appeared.

It is also being employed preoperatively as an adjunct to the delayed method of treatment and to protect the patient from peritoneal spread in ap-

pendiceal abscess where transperitoneal drainage may be necessary. It was used in about 40 per cent of the cases since the latter part of 1936.

Method of Administration.—In patients with spreading peritonitis in which the limits of the peritonitis extended beyond the operative field, sulfanilamide is now given in 0.8 per cent concentration in physiologic saline solution by hypodermoclysis.* The dosage is usually 8 Gm. the first day and is reduced about 1 Gm. a day, the amount being varied to some extent according to the response of the patient. In patients with milder infections the usual dose is 6 Gm. the first day by mouth. This is gradually reduced to 3 Gm. over a period of four to seven days and then stopped. We have not attempted to adhere to a rigid dosage schedule but cite these figures as representative of our current practice. Each day's dose is given in four installments at six-hour intervals. The blood concentration of sulfanilamide should be maintained above 5 mg. per cent and we have kept it above 15 mg. per cent in certain cases.

Complete blood counts should be made every 24 to 48 hours. If rapid anemia or leukopenia develops, the administration of the drug may have to be discontinued.

Duration of Intensive Treatment.—The decision to start fluids by mouth rested on the occurrence of audible peristalsis or the passage of flatus, a fall in temperature lasting 24 hours, abdominal relaxation on the left side, and a fall in pulse rate. With the appearance of these favorable signs suction drainage was discontinued and venoclysis stopped after the oral intake of fluids had been increased to 1,500 cc. per day.

Sulfanilamide was seldom stopped before the fifth day and often not before the seventh. Occasionally unfavorable reactions made it necessary to stop it sooner.

Sulfanilamide Reactions.—Reactions to the drug when given by hypodermoclysis are not different from those seen after oral administration. Cyanosis has been usual and should, as a rule, cause no alarm. In the very sick patient it should not be confused with the cyanosis of a failing circulation. Hyperpyrexia with or without tachycardia or leukocytosis has been the most frequent toxic manifestation. The drug-fever seldom came on before the fourth day unless the patient had previously had sulfanilamide. It must be differentiated from an exacerbation of the disease by the lack of local signs. We regard it as sufficient reason to stop the drug in a patient who is convalescing satisfactorily. The fever may persist for two to three days after the drug is stopped. We have had no fatal reactions. Reactions of all kinds have been decreased by gradually reducing the dose and stopping the drug in five to seven days whenever possible.

Some of the hemolytic *Streptococcic* infections in which sulfanilamide was first employed showed a marked tendency to relapse. It has been our experience that, peritoneal infections once overcome, as indicated by a fall of pulse rate and temperature, the passage of flatus by rectum and localization

* Crystalline sulfanilamide for this purpose was kindly supplied in sterile ampules by Merck and Co.

or disappearance of abdominal signs seldom flare up unless there is gross mishandling such as premature catharsis, too early disturbance of drains, *etc.* There have been no untoward reactions at the site of injection and the pain occasioned has not been more than is usually experienced with hypodermoclysis of normal saline solution alone.

Discussion.—The management of spreading peritoneal infections associated with acute appendicitis remains of interest because of the maintained high mortality attending this complication. Education of the laity and our medical students and practitioners in the necessity for early diagnosis and early operation has and will result in a reduction in the incidence of spreading peritonitis and, therefore, a lowering of the mortality of acute appendiceal disease, but spreading peritoneal infection will probably never be eradicated. Some years ago the late A. P. C. Ashhurst stated: "There is no problem of acute appendicitis, the problems of appendicitis are the problems of its complications." We are in agreement with this statement.

We do not believe that much can be gained by attempting to classify cases into local, spreading and general peritonitis. Local peritonitis from a perforation near the base may, in a few hours, become a very widespread infection, and general peritonitis is, in our opinion, an autopsy rather than a clinical diagnosis. Surely the operator should not attempt to verify this diagnosis, because, of necessity, this would involve extensive exposure and manipulation of the bowel. The difficulties of differentiating spreading from so-called "general peritonitis" are many, and too often the most experienced clinician cannot state just how far the process has extended. The infection may be widespread a few hours after the onset of pain and it still may be localized many hours after the beginning of symptoms. We, therefore, do not believe that operability should be determined by the time elapsed from the onset of symptoms to the time of admission to a hospital.

The most important problem in acute appendicitis is infection. Infection of the peritoneum may be present before rupture of the appendix, for gangrene or acute diffuse suppurative lesions may permit organisms to pass into the free peritoneal cavity. The difference between this type of peritonitis and that associated with perforation is one of degree; in the latter, gross soiling is more apt to be present.

While there is no universal agreement among authors as to the bacteriology of appendiceal peritonitis, it is generally believed that the colon group is the most common invader of the peritoneum in this condition. It is our opinion that when these findings are not confirmed in any one institution something is wrong with the bacteriologic study. *Streptococci* are frequently present. Some of these are aerobes, some anaerobes, and some are facultative anaerobes. Some of the *Streptococci* are hemolytic while others are not. Anaerobes of the Welch type are also found, but there is a difference of opinion as to the frequency of their presence in the peritoneal exudate following perforation of the appendix. Meleney and his associates¹¹ found them in 20 per cent of their cases; Altemeier¹² in but 1.0 per cent, while Bower¹³ states: "The *Clostridium welchii* was present in 60 per cent of instances in the flora

of spreading peritonitis in man and dog." A study of the data of the same author presented elsewhere¹⁴ discloses the fact that the *Clostridium welchii* was found in but 38.2 per cent of a total of 55 cases studied. Only 35 of the total group showed anaerobes, and it was 60 per cent of this number, or 21, which had present the *Clostridium welchii*.

The decrease in the mortality of puerperal sepsis resulting from the use of sulfanilamide, which was demonstrated by Colebrook,⁶ suggested that chemotherapy might provide a means of treatment of considerable usefulness in spreading peritonitis resulting from acute appendicitis. The administration of the drug was begun immediately after operation, because Buttle, Gray and Stephenson¹⁶ had shown that the value of sulfanilamide in the treatment of hemolytic *Streptococcus* infections in the mouse was increased by the early use of the drug.

In the early cases in the series the drug was discontinued in 48 to 72 hours when the culture failed to show hemolytic *Streptococci*. The demonstrated effectiveness of sulfanilamide against the *Escherichia coli*¹ soon caused us to use the drug when this organism was present, and before long it was employed routinely in all cases regardless of the culture report.

The method of administration we finally developed was based upon the observation which one of us had made (J. S. L.) that the blood level was more constantly maintained when the drug was repeatedly administered at relatively short intervals than when larger doses were given at infrequent intervals.

One of us (J. S. L.¹⁸) believes that the gross pathologic characteristics of the lesion are often of more importance in determining the effectiveness of the drug than is the species of the infecting organism. Infections characterized by the rapid invasion of contiguous structures, and associated with a minimal degree of necrosis, respond more favorably than do infections in which there is also considerable tissue injury and necrosis, or where the infection is confined to a local abscess.

The peritoneum is an area where infections can, and under favorable conditions do, advance rapidly. The peritoneal surfaces are richly supplied with blood vessels so that even in fatal cases it is rare to find serosal ulceration or gangrene of the tissues except in the area of primary infection. Since transudation is known to occur into the peritoneal cleft, it was of interest to determine whether sulfanilamide passed from the blood into the peritoneal transudate or exudate. In the dog receiving sulfanilamide we have found that the drug passes rapidly into fluid injected into the peritoneal cavity.

Three dogs previously anesthetized with sodium amytal were given intra-peritoneal injections of physiologic saline solution one hour after receiving a sulfanilamide solution by hypodermoclysis. One-half hour later a sample of peritoneal fluid was aspirated and the sulfanilamide concentration determined. Blood samples were taken before fluid was injected intraperitoneally and after the sample was taken. Even in this short time the level in the peritoneum had risen to nearly one-half of the blood level. Under these artificial conditions fluid is rapidly leaving the peritoneal cavity, whereas under the conditions of peritonitis fluid is being poured into the peritoneum. It is, therefore,

probable that the sulfanilamide concentration in the peritoneal cavity under the actual conditions of its therapeutic use is closer to the blood level than under the conditions of the experiment summarized in Table II.

TABLE II
CONCENTRATION OF SULFANILAMIDE IN PERITONEAL FLUID AFTER
SUBCUTANEOUS ADMINISTRATION

Dog No.	Weight Kg.	Sulfanilamide Injected Subcutaneously Mg. per Kg.	Physiological Saline Solution Injected Intraperitoneally Cc.	Concentration of Sulfanilamide in Blood			Concentration of Sulfanilamide in Peritoneal Fluid		
				Before* Mg. Per Cent	After† Mg. Per Cent	Average Mg. Per Cent	Perito- neal Fluid Mg. Per Cent	Percent- age of Mean Blood Level	
916	6.6	48	300	2.5	3.6	3.0	1.3	43.0	
917	7.7	64	300	5.5	5.7	5.6	2.2	39.3	
918	7.0	80	300	5.8	6.2	6.0	2.5	41.6	

* The first determination of the blood sulfanilamide concentration was made one hour after subcutaneous injection of the drug. Immediately after this sample was obtained, the intraperitoneal injection of saline was administered and 30 minutes later a sample of the peritoneal fluid was withdrawn.

† After the peritoneal fluid was withdrawn, the second blood sample was obtained.

The gangrenous appendix cannot be considered as a favorable site for the action of sulfanilamide, and there is no adequate reason to believe that good results would follow sulfanilamide treatment without operation.

We do not believe that anything is to be gained by inserting drains into the peritoneum and leaving the ruptured appendix behind. Drainage of a widespread area of infection is not obtained and much is lost by permitting the source of infection to remain behind. That some of the very late cases of spreading infection stand their best chances of recovery by the delayed, or Ochsner, method of treatment cannot be denied, but increasing experience has led us to believe that these cases are by far in the minority and that many of the patients now being treated by the delayed method should be subjected to immediate operation.

It is not certain that the *Clostridium welchii* plays an important rôle in appendiceal peritonitis. A trial of perfringens antitoxin in appendiceal peritonitis did not lower the mortality in the hands of the senior author. The recent favorable report of Bower¹⁹ on the treatment of appendiceal peritonitis in the dog with sulfanilamide is of interest in this connection, especially as Bower has been an advocate of the anti-Welch serum.

We do not believe that the mortality of spreading peritoneal infection can be materially affected by the use of any serums now available. For the two most common invaders, the colon bacillus and *Streptococcus*, no potent serum

is available. There is considerable difference of opinion as to whether the *Clostridium welchii* is saprophytic or pathogenic in appendiceal peritonitis. In our opinion it is not the major cause of death.

CONCLUSIONS

(1) The mortality in a series of 809 consecutive cases of acute appendicitis has been reduced from 1.5 per cent in the first 552 cases to 0.4 per cent in the last 257 cases. The improvement is, we believe, the result of the employment of sulfanilamide in all severe cases in the latter group. No other known factor was changed.

(2) A number of patients with very extensive peritoneal infection secondary to appendicitis have recovered with much less reaction than would have been predicted on the basis of experience with the first 552 cases.

(3) Sulfanilamide readily diffuses into peritoneal fluid in the experimental animal. All the available evidence indicates that the peritoneum is a favorable site for the action of sulfanilamide.

(4) In view of the fact that appendiceal peritonitis is nonspecific, the improvement in mortality and in the course of the disease obtained with sulfanilamide is in agreement with the concept of one of us (J. S. L.) that the character of the lesion is more important than the specificity of the organism in determining the effectiveness of the drug.

(5) Attention is also called to the fact that in this series no cases of intestinal obstruction due to adhesions have been encountered since the use of suction drainage of the stomach.

REFERENCES

- ¹ Kelly, F. R., and Watkins, R. M.: J.A.M.A., **112**, 1785, 1939.
- ² Editorial, J.A.M.A., **112**, 2066, 1939.
- ³ Bower, J. O.: J.A.M.A., **99**, 1765, 1932.
- ⁴ Domagk, G.: Deutsch. med. Wochenschr., **61**, 250, 1935.
- ⁵ Colebrook, L. C.: Lancet, **2**, 1237, 1937.
- ⁶ Colebrook, L. C.: Lancet, **2**, 1291, 1937.
- ⁷ Wangensteen, O. H., and Paine, J. R.: J.A.M.A., **101**, 1532, 1933.
- ⁸ Dorrance, G. M., and Nealon, S. W., Jr.: New York State Jour. Med., **35**, 119, 1935.
- ⁹ Abbott, W. O., and Pendergrass, E. P.: Am. J. Roentgenol., **35**, 289, 1936.
- ¹⁰ Puestow, C. B.: Surg., Gynec. and Obstet., **68**, 121, 1939.
- ¹¹ Meleney, F. L., Harvey, H. D., and Yayoseff-Jern, H.: Arch. Surg., **22**, 1, 1931.
- ¹² Altemeier, W. A.: ANNALS OF SURGERY, **187**, 517, 1938.
- ¹³ Bower, J. O., Burns, J. C., and Mengle: Surgery, **3**, 645, 1938.
- ¹⁴ Bower, J. O., Burns, J. C., and Mengle, H. A.: Surg., Gynec. and Obstet., **66**, 947, 1938.
- ¹⁵ Bower, J. O.: J.A.M.A., **99**, 1765, 1932.
- ¹⁶ Buttle, G. A. H., Gray, W. H., and Stephenson, D.: Lancet, **1**, 1286, 1936.
- ¹⁷ Helmholz, H. F.: Jour. Pediat., **11**, 243, 1937.
- ¹⁸ Lockwood, J. S., Coburn, A. F., and Stokinger, H. E.: J.A.M.A., **111**, 2259, 1938.
- ¹⁹ Bower, J. O., Burns, J. C., and Mengle, H. A.: Jour. Lab. and Clin. Med., **24**, 240, 1938.

THE MIKULICZ PROCEDURE *

WITH SPECIAL REFERENCE TO THE LATE RESULTS IN THE MANAGEMENT
OF CARCINOMA OF THE COLON

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ALTHOUGH successful removal of a portion of the colon for carcinoma was accomplished more than a century ago, and reported several years later,⁴² there is still great difference of opinion as to the best method of performing such a resection. Many advocate and perform "primary resection and suture" in the average case,^{10, 24} while others strongly urge the use of stage operations such as that sequence ordinarily known as the Mikulicz procedure. It was

with some hesitation that we selected such a controversial subject, recalling a discussion before this Society, just one year ago, during which the Mikulicz operation was described in very uncomplimentary terms.⁸ Our excuse for reopening the argument lies in the dearth of material to be found in the literature in regard to the *late* results that may be obtained with the Mikulicz plan in the surgical attack upon carcinomata of the large bowel. Much has been written about its relative safety, about many major and minor modifications, new types of clamps, and morbidity; but little has been written about what eventually becomes of these patients. After all, when dealing with cancer, one cannot approach the problem

timidly. Surgical safety is highly important, but thoroughness in removal and efficiency in cure are even more important. At the Roosevelt Hospital we have long been partial to the Mikulicz procedure, as the operation of choice in the average case. We have been anxious to find out if the late results obtained justify its continued application. A careful review of our records has been made from this point of view.

When Mikulicz came to this country, in 1903, to address the American Surgical Society,²⁹ he operated in the Syms amphitheater of the Roosevelt Hospital. He was the guest of Dr. George Brewer, who assisted him at the

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Johannes Mikulicz in 1878.

THE MIKULICZ PROCEDURE

operation. He wore white cotton gloves, changing them perhaps a dozen times during the course of the operation. Those present were much impressed by his technical skill. The following year Doctor Brewer spent five days with Mikulicz in Breslau.⁵ A few weeks ago one of us (H. P.) talked with Doctor Brewer, and his description of the work in Mikulicz's clinic was most interesting. He had been greatly impressed by Mikulicz's operative skill, and by the very warm personal interest he took in his patients. At a time when many of the leading European surgeons seemed to be more interested in the specimen than the patient, Doctor Brewer found Mikulicz a great exception. It was only about one year later that Mikulicz went to Vienna to be operated upon by Doctor von Eiselsberg, who found the situation entirely hopeless.

It would seem appropriate to briefly run over some of the main features of the so-called Mikulicz plan, before proceeding to the consideration of the late results. For our purposes, this term may be applied to any operation, performed in stages, that involves mobilization, the fashioning of a "double-barreled shotgun" out of the afferent and efferent loops, the prompt or delayed resection of the growth outside the peritoneal cavity, and the subsequent removal of the partition by the necrosing pressure of a clamp. Innumerable modifications have been described, but the principle remains the same. The name of Bloch³ or Paul^{33, 34} might have been applied to the operation with at least equal justification. Mikulicz did not claim originality. As a matter of fact, he pointed out²⁸ that a similar type of operation had been performed as early as "the 1870's" by several surgeons (Maydl,²⁵ Schede,⁴⁵ etc.). The early operations of Mikulicz involved the removal of the tumor itself, with but little margin of normal bowel and scant attention to the mesentery. However, his later operations were much more radical. This is obvious from a review of his section in the "Surgical System" edited, in 1904, by Bull,² which urges a margin of "three to five centimeters" of normal bowel on each side of the growth, and extensive resection of the adjacent mesentery.

Paul practiced the immediate removal of the exteriorized growth, with insertion of flanged glass tubes into the ends of the bowel. In his earlier report,³³ only two of seven resections were multiple-stage procedures, but subsequently he reported two other interesting cases in which he had adopted this plan.³⁴ Rankin has popularized and perfected the "obstructive resection,"^{37, 38, 39, 40} preceded by cecostomy or colostomy if the element of obstruction is a prominent one. However, this is, in principle, the old Mikulicz plan, and stands out in marked contrast to resection with anastomosis.

Although differences in caliber, fecal content, blood supply, lymphatics, and mobility raise varying problems in different portions of the large bowel, the Mikulicz principle has been applied to all parts of it. Lahey²² has adopted it as his usual method of handling growths of the right side of the colon, as well as the left. Rayner,⁴¹ and others, have had similar good results in applying this plan to resections of the right colon. The ileal contents are carried

off by a tube for a few days, and the subsequent temporary ileal fistula has not proved to be the great nuisance that one would expect.

Growths of the transverse colon are well adapted to management by the multiple-stage method, those situated near the flexures being adequately mobilized without much difficulty. The limbs may have to be twisted slightly as they emerge from the longitudinal incision, but this usually gives no trouble. Hartwell,¹⁹ in his careful analysis of the special group of splenic flexure growths, urged the use of multiple-stage resections, the mortality in one-stage resections being three times higher.

The sigmoid, commonest site of cancer of the colon (exclusive of the rectum), presents the ideal site for the employment of the Mikulicz procedure. Unless the mesentery is extraordinarily short, or the abdominal wall extremely thick, adequate mobilization at this site is easy. One of Paul's³⁴ early cases, operated upon under very difficult circumstances, was of this physical type. By an ingenious use of his flanged tubes, he performed a successful resection and was able to report the patient as alive and well two years later. As a matter of fact, one can occasionally "exteriorize" a carcinoma of the upper rectosigmoid, although they may have been resigned before operation to performing a complete abdomino-perineal resection. Thorough mobilization, depression of the parietal peritoneal level, and the use of iodoform gauze packing to form a bed for the growth until the second stage, will sometimes allow the application of the Mikulicz plan in these cases and the avoidance of a permanent artificial anus. It is in this group that spontaneous closure of the fecal fistula is most likely to occur. W. J. Mayo²⁷ urged the more frequent resort to this method; in low sigmoid and high rectosigmoid growths, more than 25 years ago.

The use of a "perineal Mikulicz," for low rectosigmoid growths, has been applied to occasional cases. There were none of these in the Roosevelt Hospital series. Gerster¹⁸ presented such cases before this Society in 1931 and again in 1936, and referred to Kuttner's cases. Carter⁹ has performed several such operations with encouraging results.

The actual choice of operation in a given case of carcinoma of the colon must be predicated upon four general considerations—the condition of the patient, the experience of the surgeon, the site of the growth, and the type and degree of complications. Most observers agree that the Mikulicz plan is the safest way in which one can remove portions of the colon. Ample statistical support of this belief is available, and (based upon such reports as those of Mikulicz,²⁸ Rayner,⁴¹ Moszkowicz,³⁰ Rotter,⁴³ Bolling,⁴ Anschütz,¹ Dixon,¹¹ Oppel,³² etc.) one can state, in general, that primary resection and anastomosis carries a mortality of 20 to 35 per cent, while the Mikulicz procedure, properly applied, entails a mortality of 10 to 20 per cent. Mikulicz's own mortality was 12.5 per cent. Rankin³⁷ has lowered this figure to less than 10 per cent, and has reported a series of 31 consecutive cases with only one death. It is obvious, of course, that if the multiple-stage method be re-

served for the "bad-risk" cases that are too old or too sick to stand primary resection, such low mortality figures would be impossible.

It is generally agreed that acute obstruction calls for preliminary cecostomy or colostomy, no matter what type of resection is to follow. It is a factor that is present in about 30 to 40 per cent of cases of colon carcinoma, as they come to the surgeon. Anschütz¹ noted obstruction of considerable degree in 51 cases out of 128, Brown,⁶ in 43 of 171, Mikulicz,²⁸ in 28 of 111 cases. Nearly half of the patients in the Roosevelt Hospital series showed some obstruction, and Hartwell¹⁹ noted that, in the special group of splenic flexure growths, nearly three-fourths presented acute obstruction at the time of operation. In 27 per cent of the cases in our series, a preliminary cecostomy was performed. Formerly, the use of the first-stage Mikulicz operation, with immediate decompression of the upper loop by means of a catheter, was often tried in these cases. It was far from satisfactory. One must remember that the mere handling of obstructed, edematous bowel may lead to peritonitis, even in the absence of gross soiling. Cecostomy works well as an emergency vent, but it certainly does not really divert the fecal stream, nor does it afford the opportunity for rest and cleansing of the bowel distal to it that one gets with a divided colostomy such as Cheever¹⁰ and Sistrunk⁴⁶ have urged, preferably in the right half of the transverse colon.

Critics of the Mikulicz operation point, with considerable justification, to the long morbidity, the necessity of multiple operations, the nuisance of a fecal fistula for several weeks, the likelihood of hernia, and the possibly "inadequate" removal of the lymphatic-bearing area adjacent to the growth. It has been noted that recurrence in the abdominal wound itself may occur. Rankin reported a definite incidence of these when using the "original" Mikulicz type operation, this being one of the main reasons for his modified plan which involves the removal of the growth at the primary operation.³⁷ Whipple⁴⁸ has also spoken of this possibility. There have been no recurrences in the abdominal wall in any of our cases, so far as we have been able to determine.

Possible contraindications to the Mikulicz exteriorization, as enumerated by Sistrunk⁴⁶ and endorsed by Rankin,³⁹ are to be found in the presence of adherent growths with infection of the wall of the bowel and adjacent tissues; large growths associated with infection; a considerable degree of obstruction; or occasionally in obese patients with short mesenteries. Great care and patience can often enable one to mobilize growths such as are mentioned as the fourth class above. However, traction on such mesenteries is hazardous, and in this group occur most of the cases of subsequent fatal embolism. The first three groups mentioned above as "contraindications" can often be transferred to the operable group by preliminary cecostomy or transverse colostomy. However, cure by resection after a colonic carcinoma has perforated (with abscess formation) is very rare, although it does occur.²⁰

It is true that the adoption of the Mikulicz plan means multiple operations and a long hospitalization. We feel, however, that the advocates of primary resection and anastomosis are misleading in this regard. They seem to urge

that the somewhat increased mortality is more than offset by the assurance of a single operation with prompt healing. This is, however, not always the result, by any means. Of the large series reported by Cheever,¹⁰ only 50 per cent of the primary suture cases were completely healed at the time of discharge. Twenty-seven per cent had fistulae, and the other 23 per cent had granulating wounds. The average hospital stay was 43.3 days. Of the Mikulicz cases in the same report, only 30.7 per cent were completely healed at the time of discharge, and the average hospital stay was 53 days. Among Rayner's⁴¹ primary resection cases, performed with a very low mortality, there were "several" cases of wound suppuration and of fecal fistulae. It is evident, therefore, that primary suture does not avoid complications in wound healing in a considerable percentage of cases.

As to the "wideness" of the removal of bowel and mesentery, one must be practical. The two prime factors in cure are early operative intervention and a relatively benign growth, the latter factor being the more important of the two. All surgeons of experience have seen, on the one hand, very small primary colon carcinomata with the liver full of metastases, and on the other hand, huge extensive tumors that do not recur after operation. A high percentage of excised, enlarged regional lymph nodes in these cases prove, on examination, to be inflammatory. While one must always lean toward radicalism and thoroughness in all cancer surgery, it is doubtful if many cases of cancer of the colon are saved by unusually wide excision of mesentery who would not have been saved by resection of the growth itself, with reasonably adequate margins all around. At any rate, one can certainly perform almost as radical a resection with the multiple-stage operation as in the one-stage resection. Rankin³⁹ has outlined the method of accomplishing this.

The case for primary resection and anastomosis has been admirably presented by MacFee,²⁴ who uses the simple but effective end-to-end aseptic anastomosis described by Scarff,⁴⁴ and reports a very low mortality (16.1 per cent). The whole problem is reviewed and thoroughly discussed, but little is said about late results. The dangers of primary resection and suture of the large intestine were well stated in the "Surgery" edited by Bull² some 35 years ago. The same anatomic, technical, and bacteriologic considerations seem to us to be still valid. It is a vastly different problem from anastomosis of the small intestine. We think it highly important to realize that among those surgeons who urge the multiple-stage procedures, with all their inconveniences, are many men of vast experience and great technical skill, in whose hands primary anastomosis should be as safe as is possible.^{22, 37, 26, 27, 11}

It might be well to briefly consider the routine that we employ in multiple-stage resections, before taking up the question of the late results. In the presence of obstruction, preliminary cecostomy is always performed. Unless the patient is in a very precarious condition, exploration is carried out at this time. If one is very gentle, a complete exploration can be made without unduly increasing the risk, and it enables one to take inventory and plan intelligently as to the proper future course. The first stage of the resection

follows in 10 to 15 days. Meanwhile, with subsidence of edema, the growth has usually "opened up," with the passage of material by rectum.

At the time of the first stage of the Mikulicz resection, one must employ a really adequate incision. If previous exploration has not been made, it is carefully performed in a regular sequence—examining the liver and aortic nodes first, and the growth itself last, for one may encounter a small abscess when least expected. If the growth is found to be removable (and this should be done at times, even in the presence of liver metastases), a painstaking mobilization is performed, "freeing-up" the tumor and the adjacent mesentery down to its root. This may necessitate the division of the splenocolic ligament, even when the growth is rather remote from it, for this will give much more mobility. The two limbs of bowel, as they approach and leave the growth, are then approximated and sutured together with interrupted silk sutures. A longitudinal band is selected as the site for the suturing, and two rows are often placed, slightly more than one-half inch apart. The two limbs should be approximated for a distance of at least two and one-half inches below the level of the peritoneum, and preferably more. In the presence of a functioning cecostomy, the "obstructive resection" of Rankin may be performed, with immediate removal of the growth. However, in the usual case, we still do the old-fashioned exteriorization, using iodoform gauze as a bed for the growth, if it tends to come in contact with the wound. At the time of the first-stage Mikulicz operation every patient, without exception, receives a transfusion of at least 500 cc. of blood, usually during the latter part of the operation or as soon as it is completed.

The growth is removed by cautery after 48 to 72 hours. Many surgeons remove it earlier, but this lessens the safety of the operation, due to the danger of peritonitis from inadequate sealing. For the same reason, we never take sutures in the bowel wall, in order to anchor it to the peritoneum at the time of the first stage. The peritoneum is closed snugly around the limbs as they are brought out, and we often include a small epiploic appendage in the peritoneal sutures as they are tied, but we feel that it is dangerous to sew the bowel wall directly to the parietal peritoneum.

In dividing the partition between the two sides of the "double-barreled shotgun" that has been constructed, we usually use a large Kocher clamp, having found that to be the most satisfactory in the long run. Now that they are made out of much lighter-weight metals, the newer type clamps¹⁴ are probably more desirable. The clamp is applied as soon as the growth is removed, and it should necrose the "spur" and cut through in six or eight days. It is ordinarily tightened every other day. If care is taken in its application, after careful palpation through the bowel openings, injury to small intestinal loops or to the blood supply is unlikely. It is absolutely essential that the partition be cut down deeply, even if this requires a second or even a third application of the clamp. This is tedious and annoying for the patient, but will prove very worthwhile. Rankin states that if the spur is cut down properly, "more than half" of the fecal fistulae will close spontaneously. We

have not been so fortunate, only 10 of our 51 operative survivals having had spontaneous complete closure. It is likely that we have not always waited long enough. Among the earlier cases, there were many in which closure was attempted much too soon, within 15 days of the resection. This led to many failures in closure. If the closure is delayed for four to six weeks or longer, it is usually easy to perform and much more apt to be successful. There is often some discharge of gas and fecal matter (in 21 of 37 of our cases) after closure, but this soon clears up, and reclosure is rarely necessary. We have recently found the Furniss¹⁵ clamp a very useful aid in closing these colostomies. Ordinarily, it is not necessary to open the peritoneum, but if this is done it is of little consequence, on account of the marked immunity that these patients have developed. One must always remember that these patients are prone to develop incisional herniae, and it is at this final stage operation that one can guard against this by careful dissection and adequate closure of the layers. This is another good reason for not attempting closure too soon, while the tissues are still edematous. In many of our later cases, the patients have been sent home for a few weeks before returning for closure.

Late Results.—The late results in the surgery of cancer of the colon are far more encouraging than they were at the start of the century, although, as MacFee²⁴ has pointed out, most of the cases are still of long standing when they reach the surgeon. Raiford,³⁶ reporting from the Johns Hopkins Hospital, found that in the period from 1900 to 1905, less than 25 per cent of the cases were operable, the operative mortality was 31 per cent, and only 14.6 per cent of the resected cases could be called five-year cures. From 1925 to 1930, 66 per cent of the cases were found to be operable, with a mortality of 17.3 per cent, and five-year cures in 28 per cent of the resected cases. Cheever¹⁰ found that 85 out of 154 cases were suitable for resection, and MacFee²⁴ reported that 49 per cent of the colon carcinomata admitted to the New York Hospital could be removed.

The curability of colonic cancer is one of the more hopeful aspects of cancer surgery. Late recurrences are rare, and it is highly probable that a patient who seems perfectly well three years after resection will have no recurrence. Anschütz reported 10 patients who died of recurrence following multiple-stage resection, and none of them lived more than 15 months. Of Mikulicz's cases, only one who died of recurrence could be classed as "late." This patient lived five and one-half years after operation, and is the only case of late recurrence that we have been able to find after a fairly complete review of the literature. This feature offers a marked contrast to many other fields of cancer surgery, with their disheartening late recurrences.

Late results are difficult to find in the literature, but a careful search reveals some very encouraging statistics. W. J. Mayo²⁷ reported that, of 262 resections of the large intestine for carcinoma, there were 54 per cent of five-year cures among those who survived operation. Most of these were Mikulicz type operations, this operation having been introduced into the Clinic

by C. H. Mayo about 1904, and adopted as the routine method of handling left-sided colon growths.

After summarizing the reports of Hochenegg,²⁰ Anschütz,¹ Petermann,³⁵ Moszkowicz³⁰ and Mikulicz,^{28, 29} one finds that, of 79 operative survivals, 20 patients were known to be dead of recurrence; 36 were known to be living and well, of whom 23 had lived more than three years, 19 more than four years, and 10 more than five years. Many of the other patients in the group could not be traced, and the statistics are, therefore, far from satisfactory.

Radicalism, in one's approach to colonic cancers, is fully justified by experience. Resection of adherent small bowel, or stomach, along with the primary growth, has often been followed by five-year cures, and apparently hopelessly inoperable growths may be successfully removed. When a surgeon's operative mortality in colon resections is very low, it is likely that he has not been attempting the radical cure of certain cases of borderline operability that should be given this chance, notwithstanding the increased risk involved.

We have reviewed the Mikulicz operations for carcinoma of the colon at the Roosevelt Hospital, and the present report is based on a survey of the records of 70 cases in which a carcinoma of the large bowel was resected by the Mikulicz method. Seven of these cases were deleted from the statistical survey, with what we consider adequate justification, as being in no sense a true "test" of the operation. One case had large coexisting carcinomas of the cecum and the sigmoid, the latter being handled by the Mikulicz plan. One patient presented a sudden perforation of a large growth with fulminating, diffuse peritonitis, and another had a large sigmoid growth with perforation which resulted in a large abscess that penetrated into the bladder. The remaining four of the seven deleted cases represent heroic efforts to reclaim hopelessly inoperable situations, in which multiple resections involving adherent stomach, small bowel, spleen, *etc.*, were performed in addition to an exteriorizing operation upon the primary growth. The deletion of these seven cases, which we felt could not serve as a basis for determining the efficiency of the procedure, left a total of 63 cases for study. There were two hepatic flexure growths, 11 in the transverse colon, seven at the splenic flexure, 10 in the descending colon, 29 in the sigmoid, and four in the rectosigmoid.

Mortality.—There were 12 deaths, an operative mortality of 19 per cent. There were three cases of fatal pulmonary emboli, three of cardiac failure (two of them very elderly), and one of "postoperative shock" (autopsy showed no adequate explanation). One death was ascribed to a virulent parotitis, and another was apparently due to novocain poisoning, death being sudden and unexpected while the patient was on the table. There were only two deaths due to peritonitis, one unexpected and one following the rupture of a large foul abscess during operation. The general condition of the patients seemed to represent the basis for most of the fatalities, as five of the cases were elderly, and 11 of the 12 had regional or liver metastases.

Operative Survival.—There were thus 51 operative survivals, and these

have been divided, in an attempt at clarity, into those operated upon more than three years ago, and those operated upon during the past three years. Although a longer period than three years would be desirable, experience has shown that a patient who is "recurrence-free" three years after resection of a colonic cancer is apparently likely to remain so.

A total of 37 of the cases surviving operation were operated upon more than three years ago. Fourteen of these are known to be living and 13 are apparently well, having been followed for an average of eight years since operation. The other patient has lived more than four years since the resection of a growth of the sigmoid, but now has a carcinoma in the posterior wall of the bladder. There is some difference of opinion as to its source, but we feel that it is very likely a recurrence, and are listing it as such.

Nine patients are known to have died with recurrence. Eight other patients were followed for a time and then "lost." Six of these we have considered as "dead of recurrence" in our survey. Two of them may fairly be listed as probable "cures," one having been followed seven years after operation and the other nearly three years. Both were well when last seen.

Six other patients are known to be dead, none of whom had recurrence of colonic carcinoma, and five of whom lived long enough to be considered "cured" by the operation. One died 17 years postoperatively of cardiac failure, one died at 80, five years after operation, and one died of pneumonia four years after operation, autopsy showing no sign of recurrence. Two patients died after three and one-half years had elapsed since operation, one of cerebral hemorrhage and another of primary carcinoma of the uterus. The sixth case died two years after resection, following a belated second attempt to close a small fecal fistula. Although no sign of carcinoma was found, this case was not followed long enough to be considered a probable "cure."

We feel that it is reasonable to assume that 20 of the 37 patients who survived operation were "cured" of their colonic carcinomata by the Mikulicz type of multiple-stage resection. This group, constituting 54 per cent, is made up of 13 living patients, free of recurrence for an average of eight years, two in the "lost" group who had been followed long enough to make recurrence very unlikely, and five patients who died of some entirely unrelated condition after they had lived an average of six and one-half years following operation.

Fourteen of the patients who survived resection were operated upon less than three years ago, and are thus of no value in the estimation of end-results. It is interesting and encouraging to note, however, that only two of the 14 cases are dead of carcinoma, and that the other 12 cases are living without sign of recurrence. Four of these cases are very recent, but eight cases have lived more than one year (an average of 15½ months) since operation.

CONCLUSIONS

The Mikulicz procedure is still the safest method of removing a portion of the large bowel.

In spite of all the disadvantages of the Mikulicz plan, with its multiple operations and long morbidity, we believe that it is the procedure of choice in the average resectable colonic cancer.

With careful mobilization and proper technic, a sufficiently thorough removal may be accomplished with this method, and it affords the patient a maximum chance for permanent cure.

Radicalism, in the attack on large, adherent growths of the colon, is justified by the results obtained.

Whether the operation for the removal of a cancer of the colon is to be performed in one stage or in multiple stages, painstaking resection of the neighboring lymphatic-bearing area of the mesentery is an essential part of the procedure.

Late recurrences of carcinoma of the colon are rare, and a three-year survival period is more indicative of permanent cure than is a five-year period in many other types of cancer.

A group of 63 patients is presented from the Surgical Service of the Roosevelt Hospital, on whom multiple-stage resections were performed for carcinoma of the colon. There were 51 operative survivals, and 37 of the cases were operated upon more than three years ago. A critical review indicates that 20, or 54 per cent, of these cases were apparently cured by the Mikulicz type of resection.

REFERENCES

- ¹ Anschütz, W.: Beiträge zur Klinik des Dickdarmkrebses. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, **3**, Suppl. Bnd, 488-682, 1907.
- ² Bergmann, E. von, Bruns, P. von, and Mikulicz, J. von: A System of Practical Surgery, N. Y. and Phila., **4**, 476-478, 1904.
- ³ Bloch, O.: Om extra-abdominal Behandling af Cancer intestinalis (rectum derfra undtaget), etc. *Nordiskt Med. Ark.*, N. S., **2**, Nos. 1 and 8, 1892.
- ⁴ Bolling, R. W.: Carcinoma of the Left Colon. Partial Colectomy by the Multiple Stage Extraperitoneal Method of Mikulicz. *Surg. Clin. N. Amer.*, **9**, 733-740, June, 1929.
- ⁵ Brewer, George E.: Personal communication.
- ⁶ Brown, K. P.: Carcinoma of the Colon; Its Incidence, Treatment, and End-Results. *Edinburgh Med. Jour.*, **33**, 10-18, 1926.
- ⁷ Burt, C. V.: The Modified Mikulicz Operation as Opposed to the One-Stage Procedure for Carcinoma of the Colon. *New York State Jour. Med.*, **35**, 1148-1152, 1935.
- ⁸ Discussion of Dr. Carlucci's cases, N. Y. Surgical Society, December 8, 1937.
- ⁹ Carter, R. F.: Personal communication.
- ¹⁰ Cheever, D.: The Choice of Operation in Carcinoma of the Colon. *Tr. Amer. Surg. Assn.*, **49**, 291-302, 1931; also: *ANNALS OF SURGERY*, **94**, 705-716, 1931.
- ¹¹ Dixon, C. F., and Priestly, J. T.: Factors Which Decrease Risk in Operations on Colon and Rectum. *Surg., Gynec., and Obstet.*, **57**, 206-212, 1933.
- ¹² Dowd, C. N.: The Advantages of the Two-Stage Operation of Partial Colectomy. *ANNALS OF SURGERY*, **71**, 155-162, 1920.
- ¹³ Dowd, C. N.: Technic of Partial Colectomy by the Mikulicz Two-Stage Method. *ANNALS OF SURGERY*, **72**, 681-689, 1920.
- ¹⁴ Findlay, F. M.: An Improved Clamp for the Mikulicz Procedure. *ANNALS OF SURGERY*, **103**, 471-473, 1936.
- ¹⁵ Furniss, H. D.: A New Method of Intestinal Anastomosis. *Tr. Amer. Assn. Obstet., Gynec., and Abdom. Surg.*, **47**, 26-31, 1934.

¹⁶ Gehrels, E.: Der operative Verschluss des künstlichen Afters ohne Spornquetschung. *Arch. f. klin. Chir.*, **117**, 705-715, 1921.

¹⁷ Gehrels, E.: Colon Resection. *Calif. and West. Med.*, **33**, 568-572, 1930.

¹⁸ Gerster, J. A. C.: (See discussion in footnotes), *ANNALS OF SURGERY*, **104**, 244-247, 1936.

¹⁹ Hartwell, J. A.: Carcinoma of the Splenic Flexure of the Colon. *ANNALS OF SURGERY*, **66**, 339-361, September, 1917.

²⁰ Hochenegg, J.: Zur zweizeitigen Resektion der Kolonkarzinome. *Jahresber. u. Arb. d. II. chir. Klin. zu Wien* (1904-5), 332-334, 1906.

²¹ Lahey, F. H.: Carcinoma of the Colon. *Surg. Clin. N. Amer.*, **11**, 233-241, April, 1931.

²² Lahey, F. H.: Resection of the Right Colon and Anastomosis of the Ileum to the Colon After the Plan of Mikulicz. *Surg., Gynec., and Obstet.*, **54**, 923-929, 1932.

²³ Lahey, F. H., and Jordan, S. M.: Cancer of the Colon. *New England Jour. Med.*, **265**, 1125-1131, 1932.

²⁴ MacFee, W. F.: Resection with Aseptic End-to-End Anastomosis for Carcinoma of the Colon. *ANNALS OF SURGERY*, **106**, 701-714, October, 1937.

²⁵ Maydl, C.: Ein Beitrag zur Darmchirurgie. *Wien. Med. Presse*, **24**, 437, 1883.

²⁶ Mayo, C. H., and Walters, W.: The Two-Stage Mikulicz Operation for Cancer of the Sigmoid. *Surg., Gynec., and Obstet.*, **39**, 1-4, 1924.

²⁷ Mayo, W. J.: Radical Operations for the Cure of Cancer of the Second Half of the Large Intestine, Not Including the Rectum. *J.A.M.A.*, **67**, 1279-1284, October, 1916.

²⁸ Mikulicz, J.: Chirurgische Erfahrungen über das Darmcarcinom. *Arch. f. klin. Chir.*, **69**, 28-47, 1903.

²⁹ Mikulicz, J.: On Operation on Malignant Growths of the Large Intestine. *Tr. Amer. Surg. Soc.*, **21**, 132-134, 1903.

³⁰ Moszkowicz, L.: Die Dickdarmresektion nach der Vorlagerungsmethode. *Arch. f. klin. Chir.*, **116**, 260-275, 1921.

³¹ Noehren, A. H.: Resection of Mobile Portions of the Colon by the Mikulicz Method, With a Report of Five Successful Cases. *West. Jour. Surg.*, **43**, 618-623, 1935.

³² Oppel, W. A.: Principles of Operative Treatment of Diseases of the Large Intestine. *ANNALS OF SURGERY*, **60**, 409-439, October, 1914.

³³ Paul, F. T.: Colectomy. *Brit. Med. Jour.*, **1**, 1136-1139, May 25, 1895.

³⁴ Paul, F. T.: Two Cases of Colectomy. *Brit. Med. Jour.*, **1**, 245-247, 1900.

³⁵ Petermann, J.: Erfahrungen und Erfolge bei der operativen Behandlung des Dickdarmkrebses. *Arch. f. klin. Chir.*, **86**, 53-131, 1908.

³⁶ Raiford, T. S.: Carcinoma of the Large Bowel. Part I. The Colon. *ANNALS OF SURGERY*, **101**, 863-885, 1935.

³⁷ Rankin, F. W.: Resection and Obstruction of the Colon (Obstructive Resection). *Surg., Gynec., and Obstet.*, **50**, 594-598, 1930.

³⁸ Rankin, F. W.: The Surgical Treatment of Carcinoma of the Colon. *Surg., Gynec., and Obstet.*, **53**, 229-238, 1931.

³⁹ Rankin, F. W.: Surgical Aspects of Carcinoma of the Colon. *Bulletin of the N. Y. Acad. of Med.*, **8**, 389-402, June, 1932.

⁴⁰ Rankin, F. W.: Cancer of the Colon: Notes on Its Surgical Treatment. *Surg., Gynec., and Obstet.*, **59**, 410-414, 1934.

⁴¹ Rayner, H. H.: The Treatment of Carcinoma of the Colon. *Lancet*, **1**, 136-140, 1936.

⁴² Reybard (de Lyon): Mémoire sur une tumeur cancéreuse affectant l'S iliaque du colon; ablation de la tumeur et de l'intestin; réunion directe et immédiate des deux bouts de cet organe. *Guérison*. *Bull. de L'Acad. Royale de Med.*, **9**, 1031, July, 1844.

⁴³ Rotter, J.: Zur chirurgischen Behandlung der Coloncarcinome. *Arch. f. klin. Chir.*, **102**, 651-683, 1913.

⁴⁴ Scarff, J. E.: Aseptic End-to-End Suture of Intestine. *ANNALS OF SURGERY*, **83**, 490-495, 1926.

THE MIKULICZ PROCEDURE

⁴⁵ Schede: *Verhandl. der Deutsch. Gesellsch. f. Chir.*, **7**, 126, 1878.
⁴⁶ Sistrunk, W. E.: The Mikulicz Operation for Resection of the Colon: Its Advantages and Dangers. *ANNALS OF SURGERY*, **88**, 597-606, 1928.
⁴⁷ Gordon-Taylor, G., *et al.*: Discussion of the Factors Making for Safety in the Surgery of the Colon and Rectum. *Proc. Roy. Soc. Med.*, **23**, 1214-1223, February, 1930.
⁴⁸ Whipple, A. O.: Personal communication.

DISCUSSION.—DR. CHARLES L. JANSEN (New York) said that, with Doctor Olsen, he had recently made an analysis of the cases of carcinoma of the colon admitted to the Presbyterian Hospital from 1916 to date. The series cover 489 cases. Of these, 252 had radical operations, with a complete follow-up on about 95 per cent.

Although the principle of the multiple-stage resection is a sound one in Doctor Janssen's opinion, he said that he felt that the old-fashioned type of Mikulicz operation should be discarded. It is not fulfilling the requisite of a radical method of excision of malignant tumor, because the lymph nodes which can, without greater risk, be removed are left in. Therefore, for five years he has favored a modified technic of the Rankin type. He felt that with due respect to Mikulicz, the use of his name could be discontinued on account of the confusion it causes.

TABLE I
ANALYSIS OF 195 CARCINOMATA OF THE COLON
Presbyterian Hospital, 1916 to 1935 (Inclusive)

	Three Years Ago or More		Five Years Ago or More	
	END-TO-END	MIKULICZ	END-TO-END	MIKULICZ
Total Cases:.....	61	51	47	36
Postoperative deaths.....	15 24.0%	14 27.4%	11 23.4%	11 30.5%
Lost to follow-up.....	7 11.4%	2 3.9%	11 23.4%	2 5.5%
Died of carcinoma.....	9 14.9%	9 17.6%	8 17.0%	10 26.1%
Died of other causes.....	3 4.9%	1 1.9%	3 6.3%	1 2.6%
Surviving.....	27 44.0%	25 49.0%	14 29.7%	12 33.3%
Survivors excluding operative deaths.....	58%	67%	38.8%	48%
Survivors excluding oper. deaths, and lost to follow-up.....	69%	71%	56.0%	52%
Survivors excluding oper. deaths, lost to follow-up, and died of other causes	75%	73%	63.6%	54%

Late recurrences are not by any means rare. In this group, 15 recurrences were observed after the three-year period.

The attitude at Presbyterian Hospital has been eclectic. In the group of patients operated upon three years ago or more, the end-to-end anastomosis was employed in 61 cases and the multiple-stage resection in 51. No pre-conceived idea regarding anastomosis should be held when resecting a malignant tumor. Consequently an end-to-end anastomosis will occasionally be employed. At other times, a multiple-stage and occasionally a partial colectomy with permanent colostomy will be performed. The functional results after the multiple-stage resection are quite as good as after an end-to-end anastomosis.

The operative mortality is not strikingly different—24 per cent in end-to-end, and 27.9 per cent in Mikulicz or multiple-stage operations. Both figures could be improved upon.

The follow-up results likewise do not show a great deal of difference. It should be understood that a comparison is not entirely fair, because the two groups, on account of the eclectic attitude at Presbyterian Hospital, are somewhat dissimilar.

In giving results, statistics should be given that are based on all cases operated upon. Results should also be tabulated, taking into account the operative deaths, the cases dying presumably of other causes, and the cases lost to follow-up. Doctor Janssen offered the following statistics (right colon excluded). All cases had been operated upon three years ago or more (Table I).

DR. ALLEN O. WHIPPLE (New York) emphasized two or three points brought out by Doctor Janssen: First, in dealing with malignancy in the bowel or in any part of the gastro-intestinal tract, one should not compromise with the node-bearing area. That is the chief objection to the so-called Mikulicz type of operation as compared to the Rankin type, or resection with an end-to-end anastomosis or the closed method of anastomosis such as Doctor MacFee mentioned. Doctor Whipple could not see how it is possible to obtain a thorough removal of the malignant growth unless the node-bearing area is removed as radically as possible. It is true that growths of the colon may not metastasize as quickly and as generally as is the case of gastric carcinoma; nevertheless, the principle holds. Another point to be emphasized is that in case of end-to-end anastomosis, whether by the open or by the closed method, the use of silk seroserous sutures rather than catgut sutures has a definite and real advantage in that both the suture material and the needles used can be much finer. There is less chance of leakage, which has been borne out in the statistics of the Presbyterian Hospital. Where this form of suture has been used, there has been more than 50 per cent reduction in the occurrence of fecal fistulae. In Doctor Whipple's personal experience, some 30 per cent of cases with end-to-end anastomosis have developed more or less of a fistula. Drainage was used in those cases. Since using the seroserous suture with silk, it is become exceedingly rare to have a fecal fistula.

DR. JOHN GARLOCK (New York) also emphasized the importance and value of the silk technic in surgery of the large bowel. Using fine silk minimizes to a large extent the trauma incident to the performance of an intestinal anastomosis. Doctor Garlock said he had been using fine chromic for the inner layers and silk for the outer layers. Every contemplated procedure for the treatment of carcinoma of the rectum and rectosigmoid must take into account the peripheral zone of lymphatic spread. In view of this, it is difficult to understand the rationale of the modified Mikulicz procedure for these growths. Good cancer surgery implies removal of the lymph-draining tissues as well as of the original growth. Sentimental consideration for the anal sphincter has no place in the treatment of carcinoma of the rectum. Experience in recent years has shown that a properly made colostomy causes little or no inconvenience to the patient.

Doctor Garlock took occasion to report briefly on the results of a study being conducted on his service at the Mt. Sinai Hospital in collaboration with the Bacteriologic Department. This study is being carried out by Dr. Gabriel Selye. A preliminary report will be published shortly. Inasmuch as all the small and large bowel cases at the hospital are grouped in this particular service, there has been an unusual opportunity of studying the various problems associated with diseases of these organs. Most of the

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complications following intestinal surgery can be grouped under the main headings of peritonitis and wound infections. About one year ago, Doctor Seley began to study the bacteriology of the colon cases with the idea of developing a method of conferring immunity on the patients against post-operative infection. In addition to the experimental work in the bacteriologic laboratory, he made careful aerobic and anaerobic cultures at the time of operation. These were made from retrocolic tissues, the various layers of the bowel wall underlying the tumor growth and also from the mucosal surface of the neoplasm. In more than 90 per cent of the cases a Streptococcus was isolated in conjunction with *B. coli*, the enterococcus and the other intestinal organisms. The idea occurred to Doctor Garlock to administer sulfanilamide preoperatively in the hope of destroying or curtailing the activity of the Streptococci. In March, 1938, therefore, the purposeful preoperative administration of sulfanilamide was begun in all colon cases. Thirty cases have now been treated. Since the institution of this plan, Doctor Seley has been unable to obtain a single positive culture of Streptococci, although he has used the same technic as before. There has not been a single case of postoperative peritonitis and only two minor wound infections. The cultures have revealed the *B. coli*, enterococci, *B. subtilis*, etc. Theoretically, it is assumed that the Streptococci and the *B. coli* live in symbiosis in the large bowel. By curtailing the activity of one of these, the virulence of the other is immediately diminished. The smoothness of convalescence of these patients has been noteworthy. It should be emphasized that there has been no change in operative technic which might be considered as a possible reason for the results described. These results have been so striking as to warrant a continuation and extension of the study.

DR. WILLIAM F. MACFEE (New York) said that the importance of preoperative care and postoperative support could not be emphasized too often. He noted with approbation that the obstructed cases in Doctor Patterson's series were not subjected immediately to resection. A preliminary decompression was effected in these cases and an adequate period of time was allowed for a return of the colon to an approximately normal state. He approved also of the transfusion of blood which was given in every case.

So far as the operation is concerned the preoperative complications are probably more important than the operation itself. They increase the risk no matter what kind of operation one elects to perform. Chief among these are: (1) Obstruction. (2) Infection, with or without abscess. (3) Fixation of the tumor, or short mesentery. (4) Poor general condition of the patient. It is the group of cases with complications such as these which accounts for the mortality in any series.

In regard to postoperative complications, there was, in a series of 56 cases of aseptic resections which I reported in 1937, an incidence of 16 per cent of wound infections, one of which led to a fatal evisceration. There was one internal leak with fatal peritonitis, but no occurrence of external fistulae.

The mortality for the series was nine, or 16.1 per cent. This included two patients who died of pneumonia, and one in which the aseptic resection was begun but abandoned because of a leak from one segment of colon, and the operation was concluded as an exteriorization procedure.

This is in rather striking contrast with the series of Doctor Cheever, which is quoted by Doctor Patterson. In this series, there was an incidence of 27 per cent of fecal fistulae, and 23 per cent had granulating wounds when discharged from the hospital. In speaking of primary resection and anastomosis, one should distinguish between the open type and the closed or aseptic type of anastomosis.

By way of countercomment, it may be noted that in the series presented by Doctors Patterson and Webb, all cases had a fistula for a period of from four to six weeks, and that 21 out of 37, or approximately 56 per cent, had persistent fistulae for a time after an attempt had been made to close the original fistula. Only ten of 51 cases, or approximately 20 per cent, of the series healed spontaneously.

It is also an interesting observation that when all of the 70 cases subjected to Mikulicz resection are taken into account the mortality statistics are 27.1 per cent. In the series which I reported from St. Luke's and New York Hospitals, with all cases included, the mortality for the Mikulicz procedure was 27.9 per cent. Whether a surgeon performs the Mikulicz or the primary resection with aseptic anastomosis, probably depends largely on which type he started with, or is accustomed to. Unless both the Mikulicz and the aseptic types of resection are being performed in the same Clinic, it would seem to be difficult for one to conclude that either method is safer than the other. Exception must be taken to Doctor Patterson's conclusion that "the Mikulicz procedure is still the safest method of removing a portion of the large bowel," until he has given both methods a fair trial.

I firmly believe that if the cases reported by Doctor Patterson had been performed by the aseptic method of anastomosis and undertaken with the same care that was exercised in the performance of the Mikulicz procedure, the operative mortality record, excellent as it is, would have been even better.

DR. MORRIS K. SMITH (New York) said that he had always been a devotee of the Mikulicz procedure. There are, however, certain pitfalls in its use which he had learned, sometimes through sad experience. One has been mentioned by both Doctor Patterson and Doctor MacFee, that is, the danger of stirring up peritonitis in trying to mobilize an inflamed, obstructed growth. Another difficulty is illustrated by the case of a man with a nonobstructing lesion of the descending colon. The patient was stout, and it was very difficult to mobilize the colon, so that the limbs of the spur were really too short. Things probably would have gone well if the man had not coughed so much that he eviscerated, with retraction of the proximal limb of the colon, with subsequent fatality. Looking back, a cecostomy and resection with primary anastomosis would seem to have been preferable in this case.

In one apparently very favorable case, progress was quite satisfactory until closure of the fistula. Doctor Smith had closed a number without hesitating to open the peritoneal cavity in the process, and he did so in this patient. She developed an infection and ultimately died. Since then he has tried to effect extraperitoneal closures. There have been instances, however, in which the extraperitoneal closure has failed one or more times, and a subsequent attempt in which the peritoneum was opened and the intestine mobilized has been successful.

After a deep application of the Mikulicz enterotome, the opening between the two limbs often does not extend to the orifice of the fistula on account of the curved shanks of the clamp. Ordinarily the opening has been completed to the outside before closure of the fistula, but in a case where Doctor Smith did not do this, thinking the opening made by the blades sufficient, obstruction later developed from stricture at this point and further intervention became necessary.

DR. GEORGE T. PACK (New York) asked Doctor Patterson two questions: one had to do with breaking down the figures for the patients who died with recurrence, and survived the three-year period without recurrence, into those patients with carcinoma without metastasis to lymph nodes and those who had such metastasis; and the second question was whether there

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was a histologic grading of the cancers in those patients who survived and in those who died.

DR. HOWARD PATTERSON said, in closing, that he was sorry some of those who had spoken felt that his statistics were grossly misleading. The interest of Doctor Webb and himself lay in trying to find out how efficient the Mikulicz type of procedure was in the "cure" of resectable growths of the colon. The cases deleted from the survey were those which could not possibly serve as a "test" of *any* operation. One was a young man in the twenties, who had a fulminating, diffuse peritonitis. He was thought, before operation, to have an acute perforation of a duodenal ulcer. Exploration disclosed a large growth of the sigmoid, with a perforation the size of one's thumb, and much fecal matter in the abdominal cavity. He died the next day, following exteriorization of the growth, with drainage. A second case had coexisting carcinomata of both the cecum and sigmoid. Exploration showed the former to be inoperable. It was felt that the sigmoid growth might later obstruct and, therefore, a Mikulicz resection was performed. These cases are typical of those that were deleted from the study in regard to late results. It was felt that several cases that were "lost track of" after partial follow-up are probably well to-day—but they were classed as "dead of recurrence" in the survey. The cases were not divided into those with and without extension to regional lymph nodes for the reason that the total number of cases was too small to make such a study valuable.

ADAPTATION OF THE MIKULICZ OPERATION FOR THE RIGHT COLON AND RECTOSIGMOID *

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The Right Colon.—The operation of Friedrich; removal of the lower six inches of the ileum, the cecum, the ascending colon, and about one-third of the transverse colon has been quite generally adopted for growths in the cecum and ascending colon. The growth and the lymphatic area attached are removed when the ileocolic, right colic and the lateral branches of the middle colic arteries are divided as near as possible to their origin from the superior mesenteric and middle colic vessels. The best methods of joining the ileum to the colon and of repair of the raw surface on the posterior abdominal wall are still under debate in the surgical literature.

The Mikulicz¹ method of intestinal anastomosis is apparently gaining favor among surgeons for use following the Friedrich resection. The method that has been employed with satisfactory results in performing the Friedrich resection and Mikulicz anastomosis is shown in Figures 1 to 10.

The general advantages of the Mikulicz method of anastomosis apply themselves in this instance. The method of repair of the raw surface on the posterior abdominal wall is adequate for the removal of the entire lymphatic area attached to growths in the cecum and ascending colon. Prior to the use of this means for repairing this defect the area could not be covered when an adequate lymphatic drainage field was removed.

The Rectosigmoid.—The removal of growths from the low sigmoid and upper rectal zones has passed through an interesting phase. After Lisfranc's³ perineal excision of the rectum in 1820, there seems to have been little technical progress made until 1874, when Kocher⁴ and Verneuil⁴ independently widened the scope of this operation by removing the coccyx. From this time until 1900 the development of an adequate operative approach has proceeded rapidly. In 1883, while assisting Volckmann in the removal of a sarcoma of the sacrum, Kraske saw a large portion of the sacrum removed and the sacral canal opened without untoward results. From this he rightly concluded that the lower sacrum could be resected in the operative approach to rectal carcinoma. This step provided exposure sufficient to remove a larger segment of rectum, and provided adequate exposure for reanastomosing the bowel without sacrifice of the sphincters. Primary anastomosis was first attempted, but unsatisfactory results led him to discard this for suture of the anterior half of the bowel followed by secondary closure in the sacral wound after it had begun to granulate. The first successful abdomino-perineal re-

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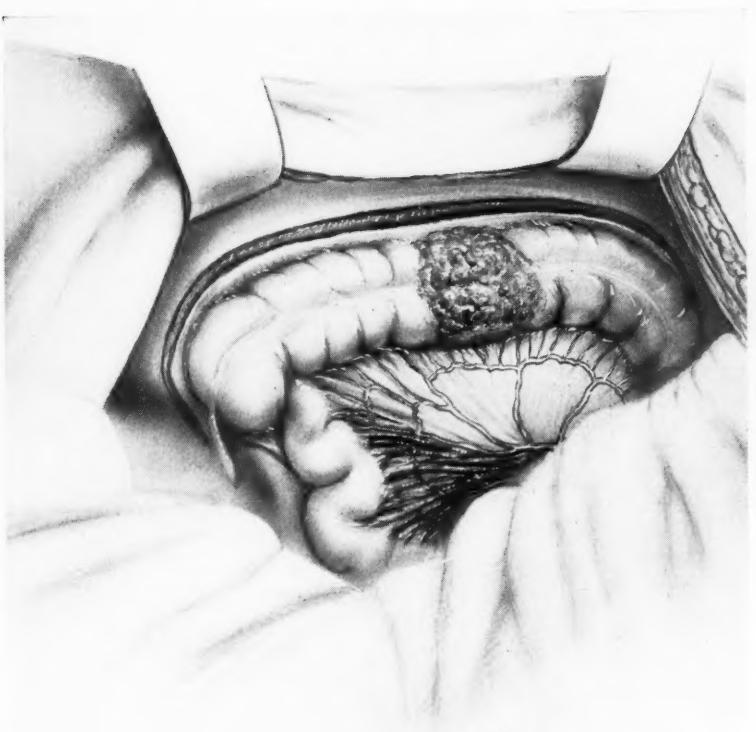


FIG. 1.—Incision through the abdomen along the lateral border of the rectus muscle sufficiently long to afford ample exposure of the entire right abdominal cavity. Open abdomen: A view of the growth, and the incision along the right lateral gutter which divides the lateral peritoneal attachment of the cecum and ascending colon.

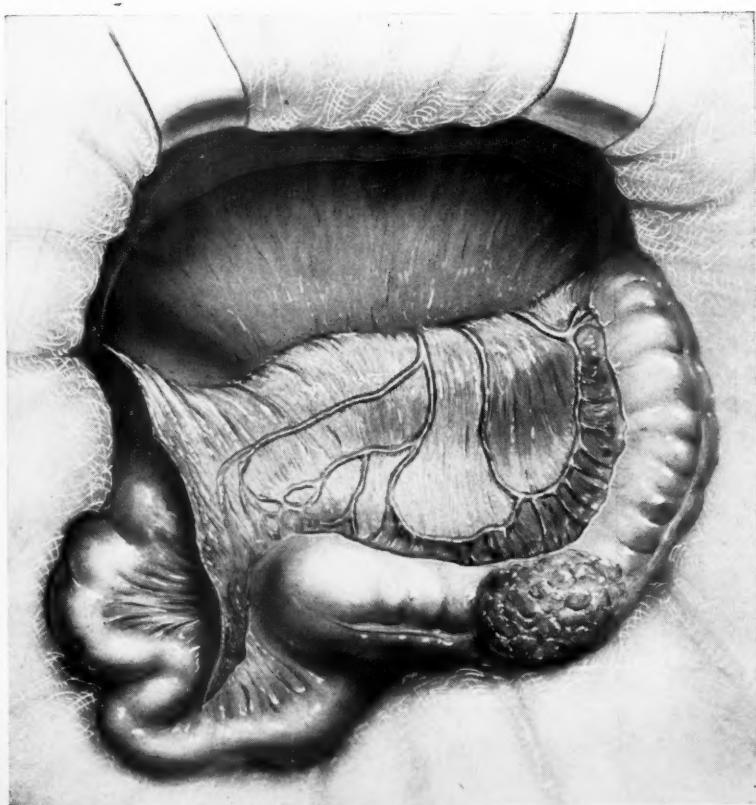


FIG. 2.—The dissection inward of the cecum and ascending colon, thereby forming a false mesentery.

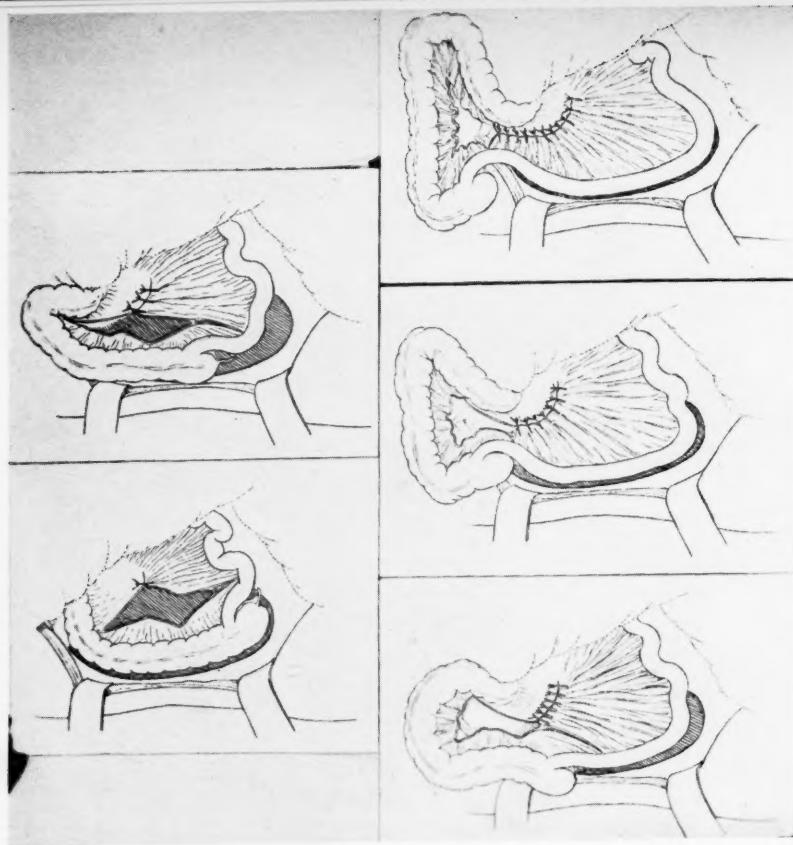


FIG. 4.—Diagrammatic representation showing the method of suture of the divided mesentery of the ileum to that of the cecum and ascending colon. As these sutures are placed, the cecum and ascending colon are raised up and through the upper angle of the abdominal incision. The last suture approximates the serous surface of the lower ileum to the transverse colon.

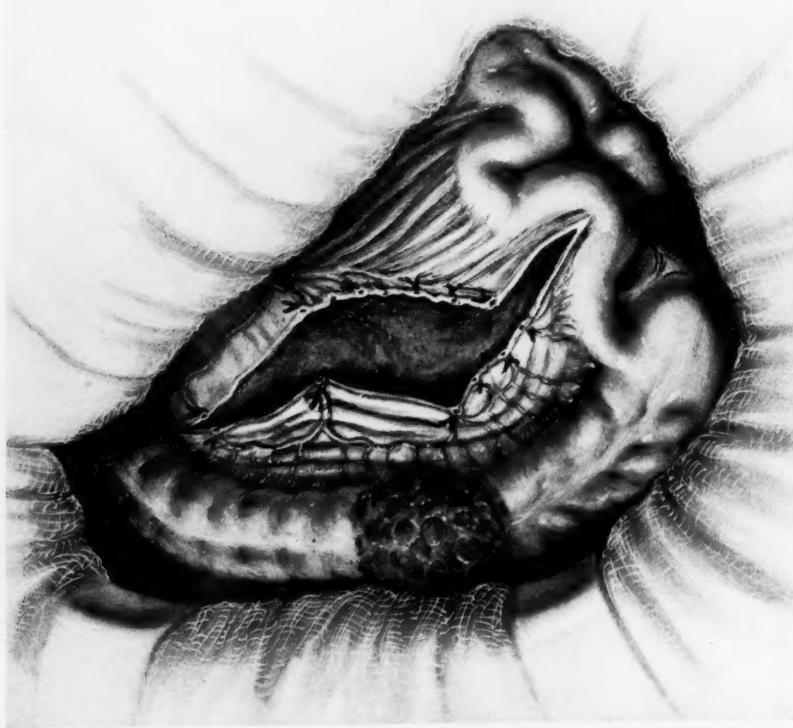


FIG. 3.—Division of the ileocecal, the right colic and the lateral branches of the middle colic arteries close to their origin, and splitting of the mesentery of the lower ileum and the false mesentery of the cecum and colon.

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section was performed by Boeckel,³ in 1896, in a patient in whom he found himself unable to deliver a growth by the Kraske operation. During this same year, the first case in which the areas of lymphatic drainage were



FIG. 5.—The mesenteric attachment completed. The white band of the colon is shown sutured to the adjacent serous surface of the ileum through which the stoma clamp will later cut a new opening. The lateral serous surface of the ileum, which naturally approximates the lateral cut surface of the posterior peritoneum, is sutured to its free border. Additional sutures are taken in the posterior surface of the mesentery of the ileum to attach it to the posterior abdominal wall from the angle of the mesenteric suture down to the lower point of attachment of the incision in the posterior parietal peritoneum. The open posterior abdominal wall is thereby completely covered by the ileum and its mesentery.

removed was performed by Giordano.³ The final contribution to the radical approach was made by Miles,⁵ in 1908, when he reported his classic abdomino-perineal operation which removed the primary growth and all the areas of

local metastasis; namely, the ischiorectal fossae, nodes along the levator ani, adjacent bowel, and the mesosigmoid and aortic nodes. The pathologic basis for the radical operation was not described in full until 1910, when Handley⁷ clearly showed the metastases present in the submucosal lymphatics 5 to 12 cm. proximally in the intestinal wall.

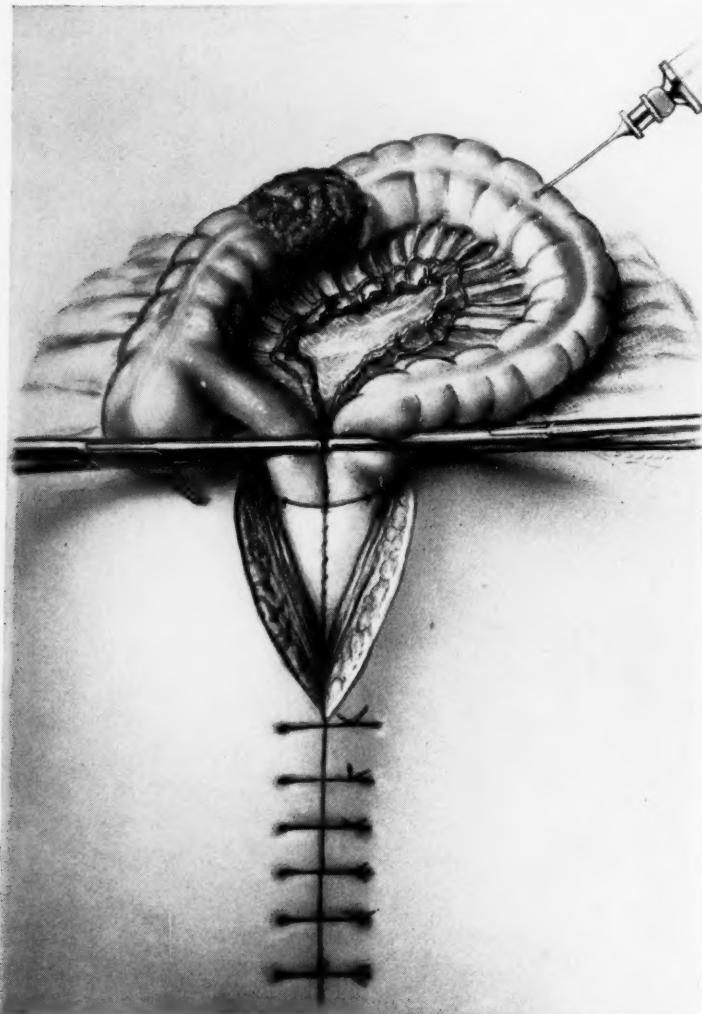


FIG. 6.—Closure of the abdominal wall in layers. Clamping of the colon and ileum. Injection of the loop with formalin solution to prevent deterioration of the specimen during the time it is left in place on the abdomen.

While the radical procedure with the permanent colostomy was being developed there was an effort made to remove the growth and preserve the sphincters. During the developmental period these operations fell into two general types. The first comprised those operations in which the growth and all bowel distal to it were removed and the proximal end brought through

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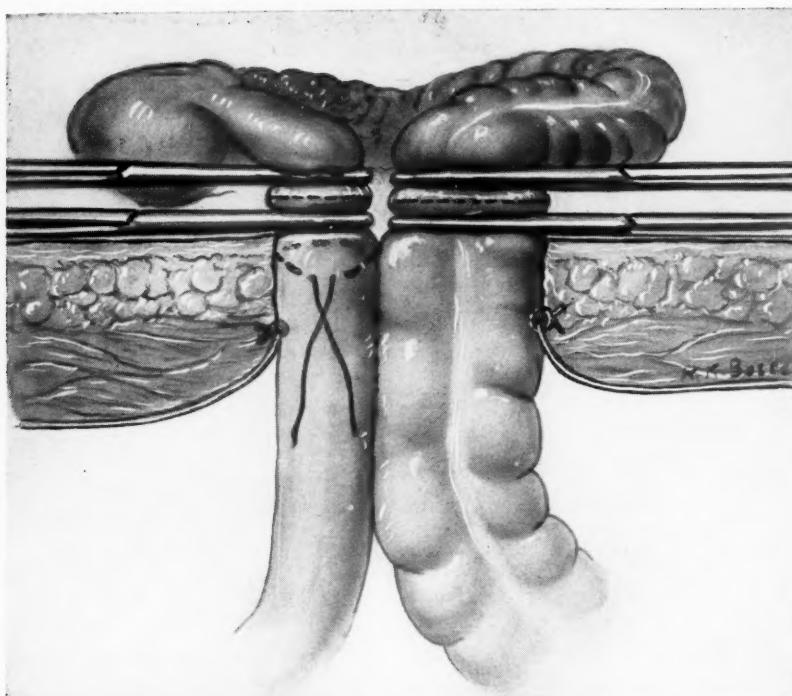


FIG. 7.—Method of attachment of the peritoneum as close up to the crushing clamps as possible, to enhance retraction of the mucous membrane edges away from the skin edges when the clamps have been removed. Purse-string suture placed around the ileum and left untied.

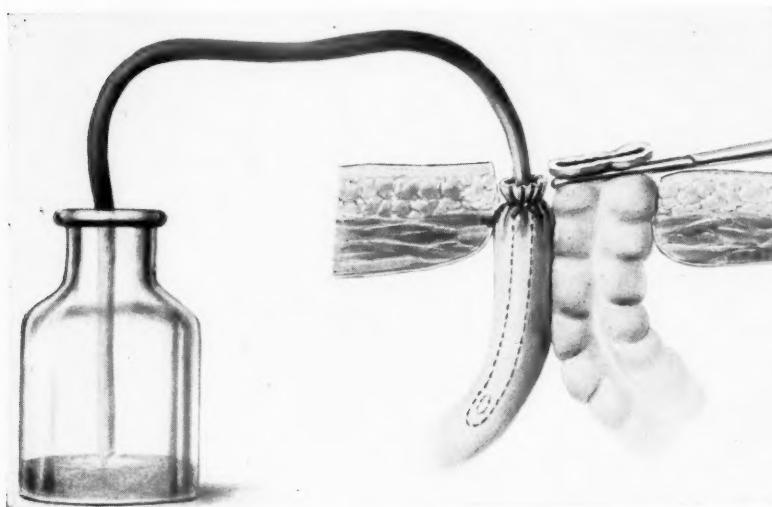


FIG. 8.—The growth has been excised and the clamp removed from the ileum. Insertion of a rectal tube into the distal ileum and tying of the purse-string suture has been done to prevent leakage of feces into the wound. The growth is removed on the second or fourth day, depending upon the degree of abdominal distention and discomfort. The ileum has retracted away from the skin margins. The clamp on the colon prevents intra-abdominal retraction. The suturing of the ileum to the colon prevents the retraction of the ileum into the abdominal cavity.

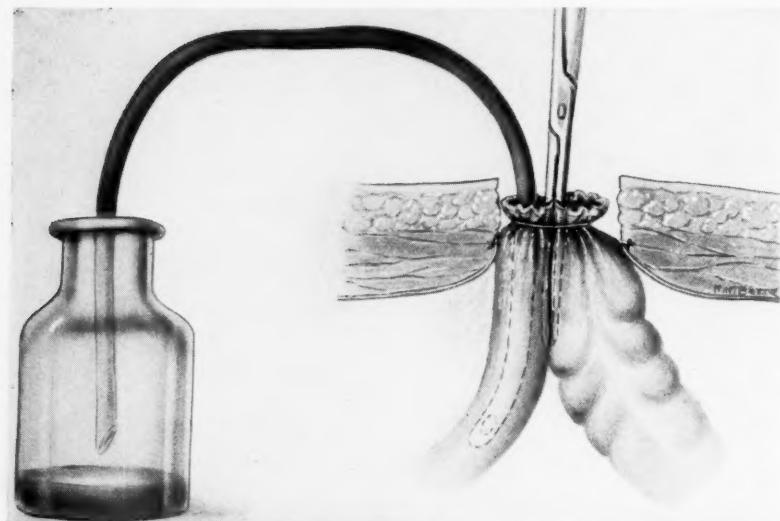


FIG. 9.—Shows a ligature passed around the proximal colon and distal ileum, colon-crushing clamp removed, stoma clamp in place, and surrounding ligature tied tightly about the open ends of the colon, stoma clamp and ileum. The stoma clamp should be supported by the dressing to prevent its full weight from resting on the intestine. The protruding ends of the colon and ileum are strangulated by the ligature, which results in the open margins resting about the level of the peritoneum as soon as the stoma clamp comes free. This greatly facilitates healing of the stoma without secondary operative closure.

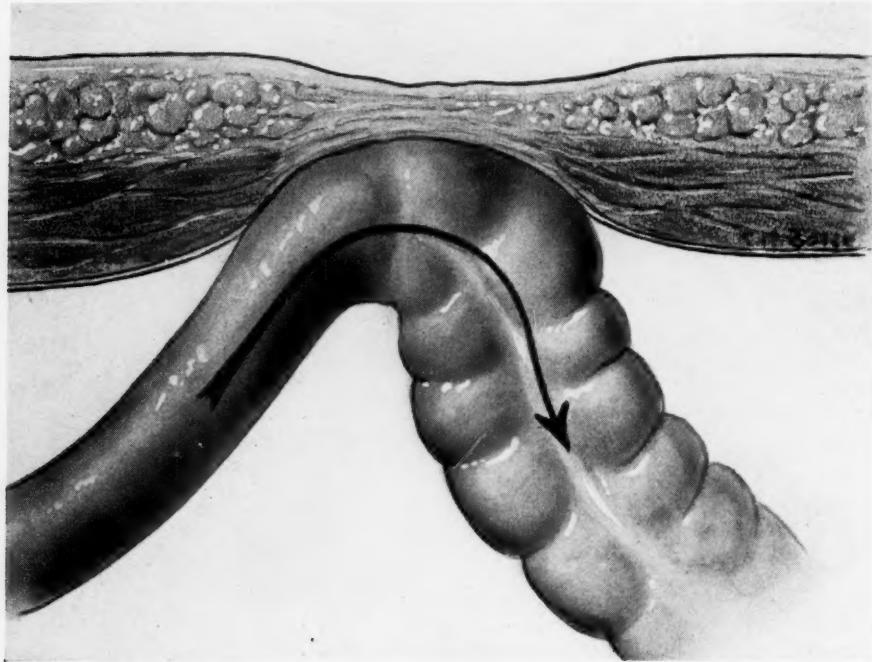


FIG. 10.—Shows the result following spontaneous closure. The last three patients have closed spontaneously in from eight to 12 weeks. The drainage on the abdominal wall of liquid feces is readily controlled in patients in whom there is primary union of the rest of the abdominal wound, the spur is cut deeply, and adhesive tape is strapped tightly across the edges of the wound over the open ends of the intestine.

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the sphincters and sutured to the skin. The second group consisted of procedures in which the sphincters were conserved and the continuity of the intestine reestablished by end-to-end suture or by intussusception of the proximal intestine into the distal segment. The major objections were the liability of stricture formation, the peritonitis hazard, and the incomplete removal of the adjacent lymphatic drainage areas.

The first application of the Mikulicz principle for reestablishment of the continuity of the rectum with conservation of the sphincters was performed by Kuttner.⁸ In 1910, he reported 10 cases in which the growth had been removed and a double-barreled colostomy made in the Kraske incision. The spurs had subsequently been divided and the colostomies closed with satisfactory functional results. There was one death in the first series. Little is to be found on this phase of the subject until 1924, when Kuttner⁹ reported several hundred cases operated upon by this method. In this series there were 36 per cent three-year cures, and 24 per cent five-year cures. Of these patients 52 per cent had perfect continence while 17.6 per cent had almost complete control.

Figures 11 to 14 illustrate the operation herein described, which has been performed upon selected cases since June, 1934. It is a combination of the Miles⁶ procedure and Kuttner's sacral anastomosis by the Mikulicz method. The remaining fistulae have been treated variously (Table I).

TABLE I

Case	Sex	Age	Opera-	Duration of	Location of Growth		Secondary Oper.	Normal Move-	Present Condition
					Rectal	Recto- sig- moid			
L. J.	F.	62	6-15-34	3 mos.		+	None	One	Mod. No dilatation
J. S.	M.	52	7-14-36	2 mos.		+	None	One	Mod. Dilatation
L. C.	M.	58	1-27-37	8 mos.		+	None	One. Excision of fistula	None
M. S.	F.	60	2-28-38	6 mos.	+		None	One	None. Fistula
M. B.	M.	48	3-11-38	4 mos.		+	None	One	+
J. M.	M.	63	2-28-38	7 mos.	+		Perfora- tion	Died	+ Fistula Died of peritonitis
G. H.	F.	43	3-26-38	1 mo.		+	None	None	Mod. Dilatation
A. F.	M.	48	8-17-38	6 mos.		+	None	None	None. Small fistula

Voluntary closure of the fistulous opening, without operative assistance, seems to be more probable in a higher percentage of cases as our experiences increase. The average length of time for closure has been three to five months. The bowels begin to move partially, on an average, at about the eighth week.

The disadvantages of this operation are legion. The patience of the surgeon as well as that of the patient is tried severely by the discharge of the fistula in the sacral position. The most important factor in promoting voluntary closure of the rectal fistula lies in keeping the margins of the mucous

membrane of the intestine far enough away from the skin edges to prevent union of the two edges. To control this factor the crushing clamps should be applied flush with the skin and with as much traction on the two loops



FIG. 11.—The first portion of the operation consists of a celiotomy at which time the mesosigmoid is mobilized. The node bearing area at the bifurcation of the aorta and the mesosigmoid is mobilized for removal during the delineation of the peritoneal leaves. The trunk of the inferior mesenteric artery is then ligated just below the left colic artery, care being taken to leave the marginal sigmoid branches intact. The rectum is mobilized from above by dissection into the hollow of the sacrum and behind the bladder. This dissection is carried down to the levator muscles taking with the rectum all fat and nodes contained in this region. A tape is tied to the rectum to facilitate delivery through the sacral wound. The abdomen is then closed by temporary interrupted sutures and the patient placed in the Sims position.

as the circulation will withstand. During the immediate postoperative period the edges of mucous membrane can be depressed away from the skin margins by packing the cavity with gauze. Operative freeing is necessary when the

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mucous membrane edges and skin margins unite. Prolapse of the sigmoid through the fistula has occurred in one patient with interference in healing of the fistula. In this instance the distal sigmoid was shortened under anesthesia.

Attempts to close the fistula after the first three or four weeks have all resulted in a breakdown of the suture line after a few days from the pressure of a collection of feces in the rectum. When this procedure is attempted the rectal sphincter must be divided (ref. Case L. C., Table I).

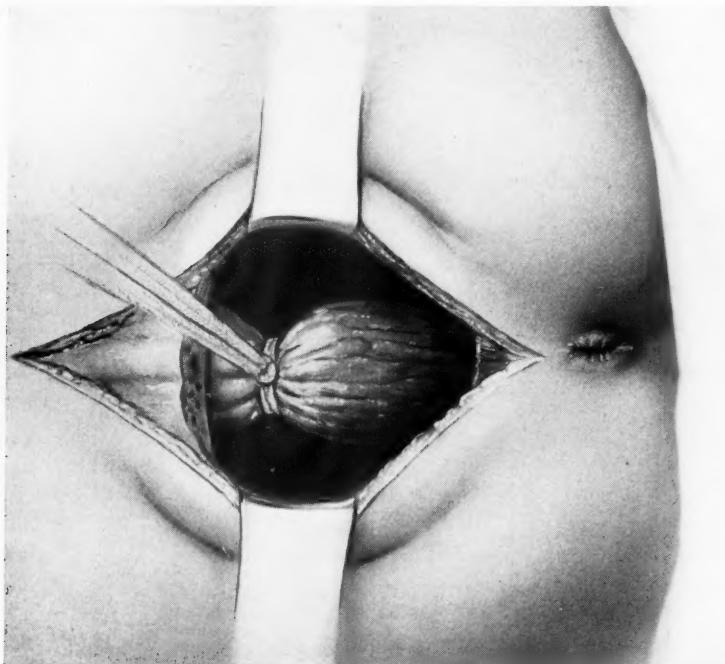


FIG. 12.—A longitudinal incision is made over the sacrum and coccyx and the latter disarticulated and removed. This step opens the pelvic cavity from below and the growth is delivered through this aperture.

The outcome in the first patient in 1934 was unusually fortunate in that the patient withstood the operation well, healed completely and has not been disturbed by the moderate stricture remaining. Had the postoperative course in this patient been as trying as in the third patient in Table I, the procedure might have been discontinued as being impractical.

The stricture of the union area that results from the procedure will necessitate dilatation during the first six months of the postoperative period. Finger dilatation without anesthesia has sufficed in all instances except Case J. S. In that patient there was a slough of the proximal sigmoid which resulted in an area of one inch of the rectal zone made up of an epithelized area of scar tissue. Following manual dilatation under anesthesia this patient has normal bowel function with finger dilatation about once a month.

There have been no recurrences in any of the patients operated upon to

date. Further observation of a larger series will be necessary to evaluate this method against the completed Miles operation.

The unquestioned advantage of this method lies in the lack of contamination of the abdominal cavity and of the pelvic cavity during the primary operation. In this one fact lies the chief justification for the time consumed and the patience necessary to carry out the procedure.

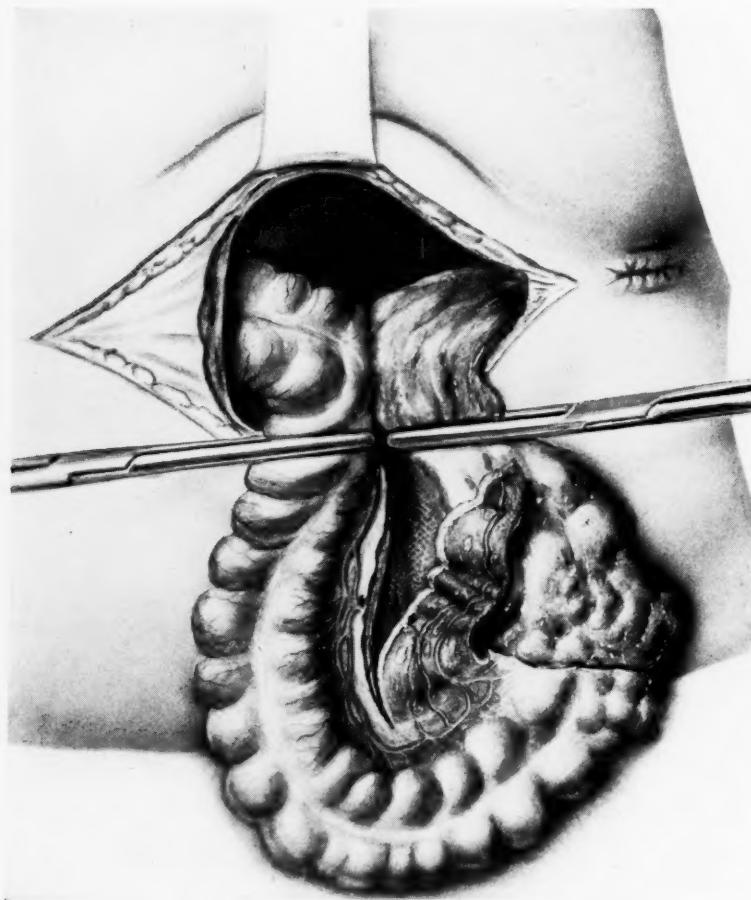


FIG. 13.—When as much healthy intestine has been delivered on each side of the growth as is possible, the adjacent limbs of sigmoid and rectum are united. The Mikulicz clamps are applied without undue tension on the circulation of the loops, including the marginal artery of the sigmoid. The wound is loosely closed about the exteriorized loop. The patient is then placed on his back and the abdomen reopened. The peritoneal incisions are closed about the sigmoid as it descends into the pelvis, thereby making an intact pelvic floor for the loops of the small intestine to lie upon.

Three to four days later, when the sacral wound has become sealed off, the growth may be removed and the marginal sigmoid artery clamped. The proximal opening is allowed to function as a temporary colostomy.

In this one advantage over other methods, the authors are satisfied when they compare their experience in this method with any other in which the sphincter action of the anus is retained. Preserving the sphincter is a matter about which there has been a great difference of opinion expressed for opera-

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tions upon growths of the rectosigmoid. The patients in our small series were not promised a preservation of the sphincter before operation. This is a matter that should be finally decided at the operating table. The primary area of metastasis of growths in the upper rectum and low sigmoid is removed by the operative procedure herein described. Those instances, in which metastases have been found outside the usual primary zone, are mainly those in which the superior, secondary zones have been invaded. This operation

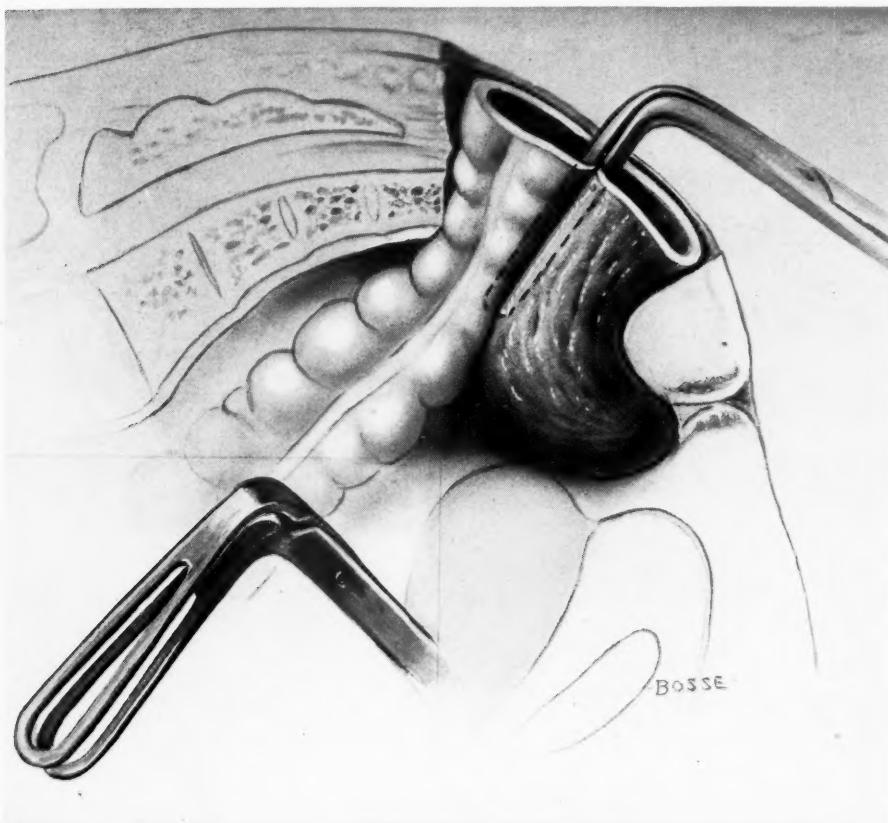


FIG. 14.—The spur formed by the resulting double-barreled colostomy should be cut away after the fifth to seventh day by the application of a crushing clamp. The olive-shaped clamp takes a larger bite which reduces the tendency for postoperative stricture.

may sacrifice the removal of a possible inferior, secondary zone that is rarely invaded by metastases. The superior, primary lymphatic zone is removed as radically as it is possible with any operative procedure.

REFERENCES

- ¹ von Mikulicz, J.: Chirurgische Erfahrungen über das Darmcarcinom. *Arch. f. klin. Chir.*, **69**, 28-47, 1903.
- ² Moynihan, Lord Berkeley: *Abdominal Operations*. Third Edition. Philadelphia, W. B. Saunders Co., **2**, 25, 1915.
- ³ Goullioud, P., and Faÿsse, G.: De l'Amputation Abdomino-Périnéale du Rectum Cancereux. *Revue de Chirurgie*, **31**, 711-735, 1905.

⁴ Mayo, C. H.: Evolution in the Treatment of Cancer of the Rectum. *J.A.M.A.*, **40**, 1127-1129, April 25, 1903.

⁵ Miles, W. Ernest: A Method of Performing Abdomino-perineal Excision for Carcinoma of the Rectum and of the Terminal Portion of the Pelvic Colon. *Lancet*, **2**, 1812-1814, December 19, 1908.

⁶ Miles, W. Ernest: The Radical Abdomino-perineal Operation for Cancer of the Rectum and of the Pelvic Colon. *Brit. Med. Jour.*, **2**, 941-944, October 1, 1910.

⁷ Handley, W. Sampson: Hunterian Lectures on the Surgery of the Lymphatic System. *Brit. Med. Jour.*, **1**, 922-929, April 16, 1910.

⁸ Kuttner, H.: Zur Operation hochsitzender Rektumkarzinome. *Zentralbl. f. Chir.*, **37**, 604, April 23, 1910.

⁹ Kuttner, H.: Soll man bei der Operation des Rektumkarzinoms in jeden Falle den Sphinkter opfern? *Zentralbl. f. Chir.*, **51**, 1110-1120, May 24, 1924.

¹⁰ Lahey, F. H.: Resection of Right Colon and Anastomosis of Ileum to Transverse Colon after Mikulicz Plan. *New England J. Med.*, **206**, 315-322, February 18, 1932.

Idem: *Surg., Gynec. & Obst.*, **54**, 923-929, June, 1932.

¹¹ Woodhall, B.: Modified Double Enterostomy (Mikulicz) in Radical Surgical Treatment of Intussusception in Children. *Arch. Surg.*, **36**, 989-997, June, 1938.

DIAGNOSTIC PARACENTESIS IN SUSPECTED INTRA-ABDOMINAL HEMORRHAGE

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TRAUMATIC RUPTURE of abdominal viscera may be among the most difficult and treacherous of diagnostic problems which confront the surgeon. To simplify this perplexing situation, the use of abdominal paracentesis has been suggested as a quick, simple, safe and satisfactory means of determining the presence of intra-abdominal hemorrhage. What with the steady progress of high speed mechanization and the ever increasing tempo of civilization, the incidence of this catastrophe is definitely on the increase.

Commonest among visceral injuries produced by nonpenetrating abdominal trauma is rupture of the liver or the spleen, or both. Gill, in discussing the incidence of subcutaneous rupture of abdominal viscera, states that rupture of the liver comprises 59.9 per cent of these injuries, while injury to the spleen accounts for 33 per cent. In other words, 92.9 per cent of such injuries are associated with intra-abdominal hemorrhage which, if not expeditiously cared for, will result in tragedy. Boljarsku¹ reports a mortality of 83.3 per cent following rupture of the liver. In a series of cases operated upon, those subjected to surgery within the first two or three hours suffered a mortality of 15 per cent, while delay of 24 hours or more caused a rise in the mortality rate to 50 per cent. Thole⁵ records a mortality of 36 per cent for the first six hours, and 86.3 per cent in those seen after 24 hours.

The mortality following rupture of the spleen, in a series of 12 cases reported by B. M. Vance,⁶ was found to be 25 per cent, although it is usually quoted as being higher. That the occasional case will survive in spite of neglect has been repeatedly shown. The well-known tendency of delayed hemorrhage in splenic rupture makes the latter even more treacherous in its subtle potentialities. From such evidence one must conclude that early enterprise is the prelude to success, while procrastination is fraught with danger, for these patients, once past the stage when surgical intervention is possible, follow a rapidly failing course and are soon beyond help of the most energetic supportive measures.

Rupture of the liver or spleen is too often associated with other serious injuries which serve to confuse the issue. Multiple fractures, head injuries, lower chest trauma, shock from exposure, and countless other factors may obscure the diagnosis in such a way as to far overshadow the insidious progress of intra-abdominal hemorrhage. The misfortune of operating upon such cases too late, or not at all, is probably of more common occurrence than would ordinarily be suspected, and for this reason one seems justified in reporting two instances in which abdominal paracentesis was employed to

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substantiate vague but suggestive evidence of intra-abdominal hemorrhage. In each case the abdominal cavity was found on exploration to contain over 1,000 cc. of blood, with free bleeding of alarming magnitude. Delay, sufficient to have warranted surgical intervention upon clinical findings only, would certainly have proved fatal in one instance, and probably in both.

A brief survey of the literature reveals that abdominal puncture for diagnostic purposes was first described by Solomon, in 1906. Sahli advocated its use in diagnosis of appendiceal abscess and, in 1912, Panichi reported its employment. In 1921, Savariaud⁴ described two cases of ruptured liver diagnosed by abdominal puncture. Both recovered following operation. In a third case, which proved to have a ruptured spleen, puncture was undertaken after several hours' observation. The diagnosis of hemoperitoneum was made, but surgery was of no avail. Delotti, in 1922, reported eight cases of hemoperitoneum, confirmed at operation, in which six of 11 exploratory punctures were negative. He attributes this failure to the use of a short, fine needle only slightly larger than the average hypodermic needle. Denzer devised a trocar with a capillary tube for the study of peritoneal fluid in infants. In 1925, Neuhof and Cohen⁵ published an interesting article on a large series of cases in which abdominal puncture was employed in the diagnosis of acute intraperitoneal disease. Several traumatic cases were included. Vance reported its value in a patient with a ruptured spleen. For the procedure, various writers have used needles ranging in size from a large hypodermic needle to that of a lumbar puncture needle. A small trocar was used by some.

Technic of Procedure.—In the two cases herewith reported, a trocar, 0.5 cm. in diameter, was introduced at a point just lateral to the rectus muscle and 2.5 cm. above the umbilicus. Novocain was injected down to the peritoneum. A small skin incision was made and the trocar introduced on either the right or left side, depending upon the location of the injury. On withdrawal of the plunger point, blood welled up in each instance. The plunger point was reintroduced, the trocar withdrawn, a sterile dressing applied, and the patient sent to the operating room immediately.

CASE REPORTS

Case 1.—At 3:00 P.M., July 22, 1937, M. S., colored, female, age 17, walked into the University of Maryland Hospital, suffering from a stab wound of the left chest, said to have been inflicted with a penknife at 1:00 A.M. the preceding morning (14 hours previously). The wound, 1 cm. long, passed through the eighth interspace in the left posterior axillary line.

Examination revealed no evidence of fluid or air in the chest. The abdomen was negative and pulse normal. The wound was dressed and the patient admitted for observation. About two hours after admission the patient felt weak, sat up and fainted. Pulse 100; blood pressure 100/48. The abdomen was somewhat distended and doughy to palpation, but exhibited no tenderness or muscle resistance. There was questionable dullness in the flanks. Paracentesis through the left abdominal wall revealed blood and the patient was sent to the operating room immediately. As her condition was becoming rapidly worse, intravenous fluids were administered.

Operation.—Under gas-oxygen-ether anesthesia, the abdomen was opened through an upper abdominal transverse incision. The peritoneal cavity was found to be full of

blood, 700 cc. of which was collected in citrate, as soon as the splenic pedicle could be compressed between the fingers, and autotransfusion was begun. A small wound, 1 cm. in length, was found at the upper pole of the spleen. Bleeding was controlled with one mattress suture of well softened No. 2 catgut. The abdomen was closed, and the patient returned to the ward in good condition. Eight days postoperatively, she developed an intestinal obstruction, and was reoperated upon through a left rectus incision. The obstruction was released and recovery thereafter was uneventful, the patient being discharged on the twenty-seventh day.

Case 2.—On July 22, 1937, W. M., colored, male, age 28, was admitted to the University of Maryland Hospital, immediately after having been kicked in the right chest. The patient was intoxicated, but was apparently suffering considerably.

Examination revealed marked limitation of expansion of the entire right chest with dullness extending from the point of the right scapula downward. The entire lower right chest was extremely painful, even to gentle pressure, and the right upper rectus and flank muscles were rigid, in contrast to the fair relaxation of the abdominal muscles on the left side. Blood pressure 90/50; pulse 100. Having just demonstrated the efficacy of diagnostic paracentesis in the first case not two hours previously, the procedure was repeated without delay. The trocar was introduced on the right side this time and blood welled up on withdrawal of the stilet. The patient was sent to the operating room, and operated upon within one-half hour of his injury.

Operation.—The abdomen was opened through an upper transverse incision, and the peritoneal cavity was found to be filled with blood. A rent in the right lobe of the liver, four and one-half inches long, extending from the dome posteriorly well through the lower edge, was revealed; the bleeding was profuse. The tear was closed with four mass sutures of well softened, double No. 3 catgut. As bleeding appeared to be completely controlled, the abdomen was flushed with hot normal saline solution, and closed without drainage. The patient was returned to the ward in fair condition, but on the second postoperative day, developed signs of pneumonia in the right base. He recovered from this and was discharged on the seventeenth day following operation.

CONCLUSIONS

- (1) Abdominal puncture as described above is easily, quickly, and simply performed.
- (2) Danger of visceral injury is negligible.
- (3) It substantiates at once, and without question, the uncertain diagnosis of hemoperitoneum, which may otherwise be very difficult to make.
- (4) The loss of valuable time, due to uncertainty, is obviated.
- (5) If blood is not found, no harm has been done, but it must be remembered that delayed bleeding is commonly seen in rupture of the spleen.

REFERENCES

- ¹ Boljarsku: Beitr. klin. Chir., **89**, 587, 1914.
- ² Delotti: Bull. Soc. d. Chir. d. Paris, **48**, 1174, 1922.
- ³ Neuhof, H., and Cohen, I.: ANNALS OF SURGERY, **83**, 454, 1926.
- ⁴ Savariaud: Bull. Soc. d. Chir. d. Paris, **47**, 878, 1921.
- ⁵ Thole, F.: Neue Deutsch. Chir., **5**, 4, 1912.
- ⁶ Vance, B. M.: Arch. Surg., **16**, 631, 1928.

RECTAL MALFORMATION

CASE REPORT

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IN this preliminary report, a single case of congenital absence of the anus and lower rectum is being presented. It illustrates the value of preoperative diagnosis by roentgenologic study in determining whether the operative approach should be perineal or abdominal. Furthermore, the author would like to present a new method of lining the fibromuscular space between the anus and rectum in cases where the rectal pouch cannot be brought down and sutured to perianal skin.

Case Report.—Infant M. D., female, born at 10:45 A.M., April 12, 1938, following a normal delivery. A diagnosis of imperforate anus was made when no meconium was passed at the time of delivery.

Physical Examination.—Eighteen hours after birth: The patient was a rather puny infant, with rapid and shallow respirations. The abdomen was uniformly distended; there were no masses palpable. Upon straining, there was some bulging of the entire perineum and no particular area seemed to "point." (This is in contrast to the lack of bulging noted during the first eight to 12 hours after delivery.) A very superficial puckering of the skin was noted where the anus would normally have been located. This was bisected by the median perineal raphe, which extended from the posterior fourchette toward the coccyx. Stimulation of the area with forceps elicited slight, but questionable, contraction of the underlying sphincter.

The external genitalia appeared normal, but search for a urinary meatus failed to reveal any. The child had not voided up to the time of operation—probably incidental to beginning dehydration. The child voided ten hours after operation and continued to do so until death, although the meatus was not identified until postmortem examination was made.

Roentgenologic studies were carried out as have been suggested by Wangensteen and Rice.³ The child was held up by the feet in front of a vertical screen and a plain roentgenogram of the abdomen obtained. It has been noted by Ladd and Gross,² and Berman,¹ that errors in diagnosis may easily occur during the first 24 hours of life. We have confirmed this by taking roentgenograms at eight, 18, and 24 hour intervals after birth, and the findings have, almost invariably, shown that the longer one can reasonably wait before operating, the more accurate will be his preoperative roentgenologic examination. Berman¹ has suggested that the fluoroscope be used and that massage of the abdomen, especially over the sigmoid area, be made so as to facilitate the migration of gas into the rectal pouch. The rationale of taking this preoperative roentgenogram is that intestinal gas will seek the highest point in the obstructed intestine. With the child in the inverted position, this should be the blind rectal pouch.

In this case the roentgenogram taken at eight hours showed no gas visualized. However, by waiting until the period between 18 to 20 hours, we were able to demonstrate in this, and in the majority of other cases seen to date, the level of the rectal pouch.

The usual preoperative subcutaneous injections of saline and glucose were administered and the infant was operated upon, 21 hours after birth.

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Operation.—With the child in the lithotomy position, two incisions were made across the anal area (Fig. 2). The apex of each skin flap was elevated and a skin flap obtained by subcutaneous dissection. The skin flaps were freed backward for approximately 2 cm. Blunt dissection was next carried out to create a tunnel from the perianal skin to the rectal pouch. This was effected within the sphincter, and most of the deeper dissection extended posteriorly along the hollow of the sacrum into the space normally occupied by the rectum. This direction was followed to avoid injury to the genito-urinary tract. The rectal pouch was identified at a level of 3½ to 4 cm. from the skin. It was freed around its edges, especially posteriorly and laterally, until one could feel the promontory of the sacrum with the index finger. After this procedure, traction failed to bring the

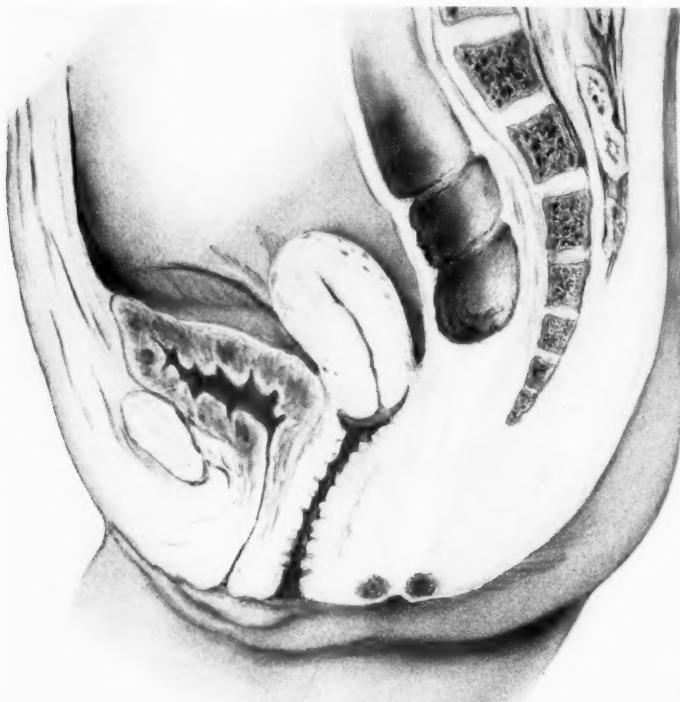


FIG. 1.—Midline section showing level of rectal pouch and position of sphincter muscles.

pouch down to the level of the perianal skin. We had anticipated this with such a high-lying blind rectal pouch, and the skin incisions had been made accordingly.

The apex of the rectal pouch was next opened and the meconium allowed to escape. The operative field was flushed out with peroxide and saline, and the apex of each skin flap sewn to its adjacent rectal wall (Fig. 5). Silk sutures were used, which included the entire thickness of the bowel wall. They were left long and hung out through the newly created anorectal canal. Upon release of traction, the rectal pouch ascended and drew the skin flaps upward with it (Fig. 5).

The intestinal tract thus created had, therefore, an opening through the sphincter, and there was some degree of continuity between the edges of the skin and mucosa. A No. 18F. catheter was left in place at the conclusion of the operation.

Subsequent Course.—The postoperative course was uneventful, and by the twenty-fifth day the canal would admit a No. 28F. catheter. The scar tissue was firm, however, as it is usually three to four months before such canals become soft and pliable. Unfor-

tunately the child developed an intractable diarrhea during the last five days of life and expired 33 days after birth.

Autopsy.—There were no general findings other than dehydration and signs of rapid cachexia. There were no associated congenital anomalies. Examination of the colon revealed it to be of normal caliber throughout. There were no areas of stenosis, bands, adhesions, or dilatations. The rectal pouch ended just below the level of the reflection of the peritoneum and the anorectal canal was patent, and admitted a No. 28 F. catheter.

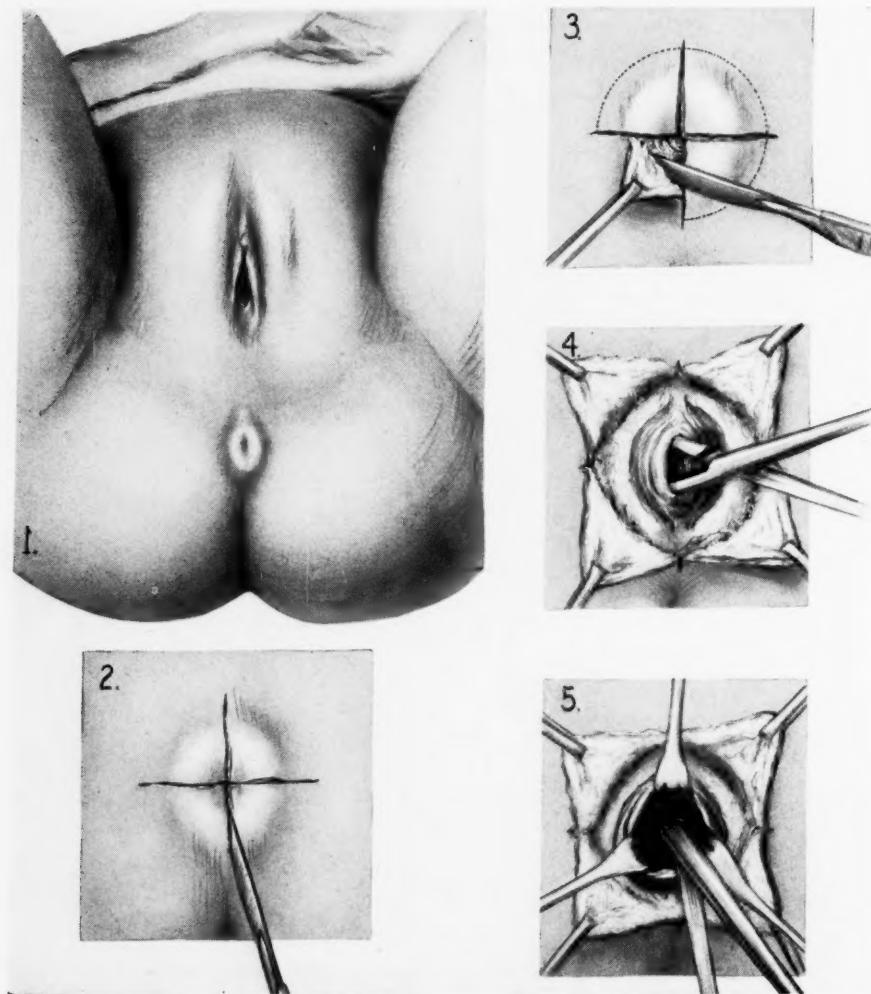


FIG. 2.—(1) Appearance of perineum before operation. (2) Line of incision. (3) Dissection of skin flaps. (4) Blunt dissection of sphincter. (5) Creation of intraspincteric tunnel.

The skin flaps had remained *in situ* in three places, and epithelialization between the flaps had occurred. The area where the one flap had become detached was a smooth fibrous area which, no doubt, would have epithelialized later.

Pathologic Examination.—*Gross:* The entire gross specimen was sectioned by Col. Eugene Whitmore of the Department of Pathology at Georgetown University Medical School, to whom I am indebted for the sections which showed:

(1) There was continuity between skin and mucosa in over seven-eighths of the circumference of the newly constructed anorectal canal.

RECTAL MALFORMATION

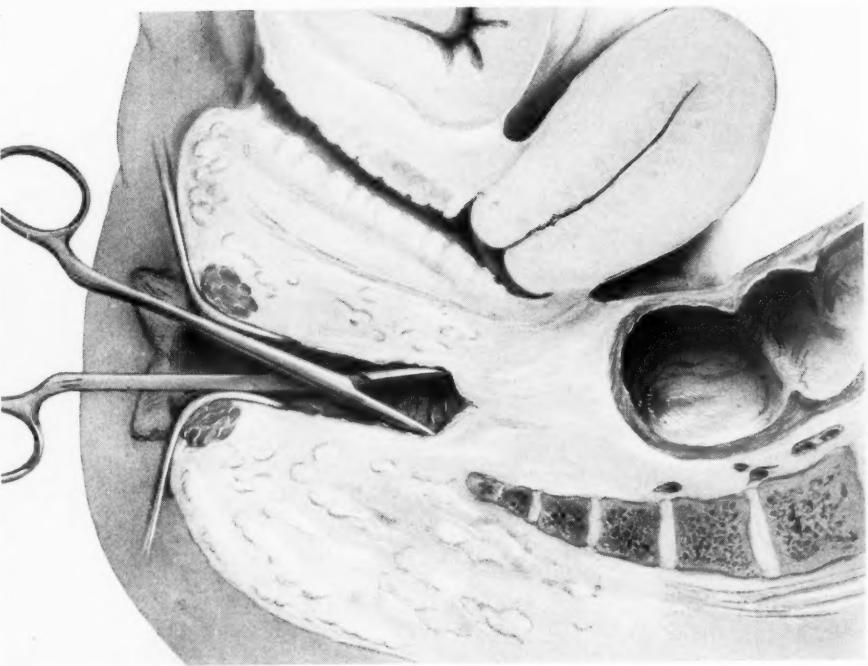


FIG. 3.—Creation of fibromuscular canal through pelvic structures by blunt dissection.

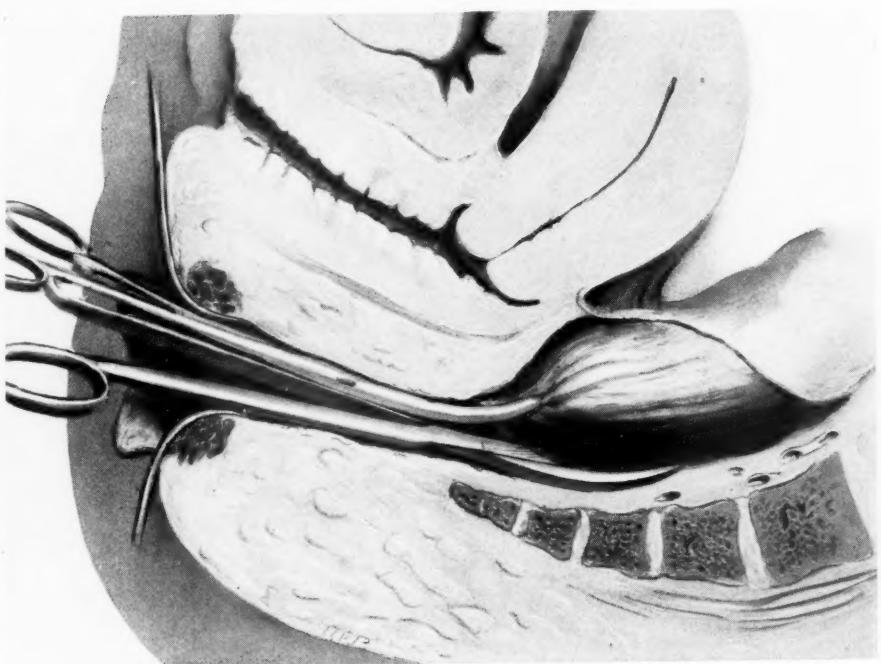


FIG. 4.—Traction on rectal pouch, with blunt scissor dissection of posterior and lateral wall areas.

(2) The fibrous tissue incident to the amount of work done was of a moderate amount.

(3) The sphincter muscles were in their normal position at the anal orifice and appeared to be of normal size and histologic structure.

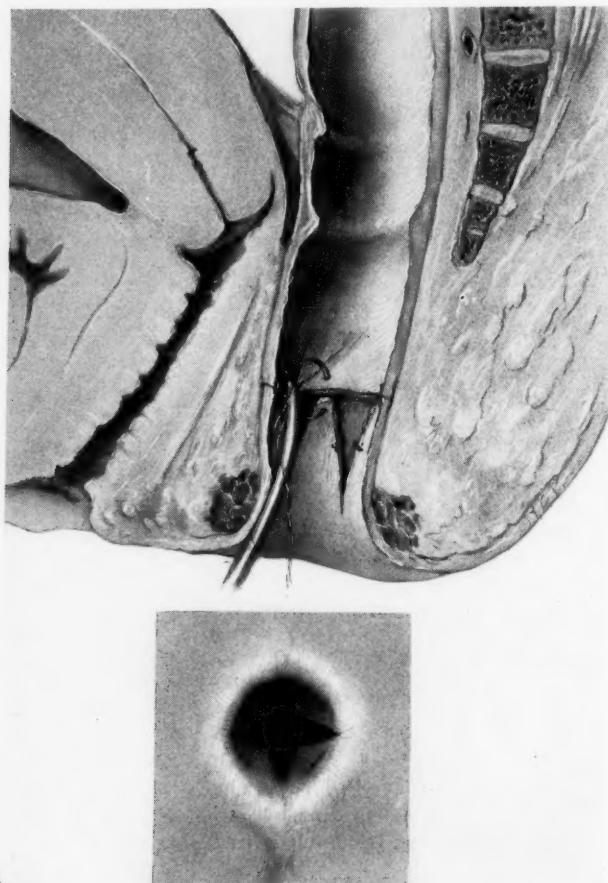


FIG. 5.—Rectum mobilized and brought down as far as possible. Suture of skin flap to lower edge of rectum. Insert shows appearance from below.

Discussion.—In discussing this case in particular, it is seen that here we had a congenital defect that would fall into Type III of Ladd and Gross.² It is felt that these authors have advanced the most recent acceptable method of classification, as far as it pertains to treatment. In this group, the rectal pouch may end a variable distance from the anus. If it is low and can be mobilized by dissecting upward along its posterior and lateral margins, it may be brought down and sewn directly to perianal skin. Continuity of skin and mucosa is established and the formation of a fibromuscular canal lined with mucosa is assured. This is important, as failure to establish continuity of epithelial surfaces tends to fibrous tissue contracture and stricture formation. Recurrent stricture, requiring long and continued periods of dilation, occurs in

cases in which an unlined fibrous tissue canal has been formed. However, if the rectal pouch is high, or it cannot be mobilized and brought down to skin by a perineal approach, it is usually necessary to perform a colostomy. In Ladd's series of 117 cases of Type III abnormality, 99 had perineal operations attempted. Of these, 85 (86 per cent) were successful. The remainder necessitated the formation of a colostomy. Abdominal operation and colostomy has, in the past, been the procedure of choice when the rectal pouch was too high to be brought down after a perineal approach. The mortality of an abdominal operation that follows a perineal operation has been close to 100 per cent. These infants usually cannot stand two operations, *i.e.*, perineal and abdominal.

This type of case is one in which colostomy alone, or unsuccessful perineal operation followed by colostomy, has usually been done. If the child lived with a functioning colostomy, the anorectal abnormality remained uncured unless corrected at some later date.

The author apologizes for reporting only one case treated as outlined. However, this is a preliminary report on a series of cases treated by various procedures. In a field where no single individual's experience is great, it is felt that the operative technic presented, even if slightly modified, may be of some value. This should be particularly true in cases where the rectal pouch cannot be brought down to skin level.

SUMMARY

A single case of congenital absence of the anus and lower rectum is reported. The value of preoperative roentgenologic studies, to locate the level of the rectal pouch, is illustrated by this case. Furthermore, it is felt that while positive roentgenologic findings may be conclusive as to the level of the rectal pouch, negative findings should call for repeated studies.

A new technic of operative procedure is presented, which appears to increase the scope of perineal approach.

The structural utility of the operation is confirmed by the autopsy findings.

It is hoped that the method may be of some value to others confronted with the choice between colostomy and perineal operation.

REFERENCES

- ¹ Berman, J. K.: Congenital Anomalies of the Rectum and Anus. *Surg., Gynec. and Obstet.*, **66**, 11, 1938.
- ² Ladd, Wm. E., and Gross, Robert E.: Congenital Malformation of the Anus and Rectum. *Amer. Jour. Surg.*, **23**, 167, 1934.
- ³ Wangensteen, O. H., and Rice, C. O.: Imperforate Anus—A Method of Determining the Surgical Approach. *Amer. Jour. Surg.*, **92**, 77-81, 1930.

CHRONIC HYPERTENSION PRODUCED BY CAROTID SINUS AND AORTIC-DEPRESSOR NERVE SECTION*

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HERING'S DEMONSTRATION¹ of acute hypertension in various animals, especially the rabbit, after bilateral section of the carotid sinus and aortic-depressor nerves, was followed by his inquiry into the possibility of producing chronic hypertension by the same means. The results of his investigation were only partially successful. His pupils, Koch and Mies,² in 1929, employing rabbits, with a slight variation in technic, reported more substantial hypertensive results, ranging from 125 to 178 Mm. of mercury over a period of months (maximum of 511 days). In 1931, Koch³ observed the production of chronic hypertension of several months' duration by similar means in dogs. In the same year, Heymans and Bouckaert⁴ published their first series of studies on chronic hypertension in dogs, reporting values as high as 250 Mm. of mercury. In 1933, Kremer, Wright and Scarff⁵ confirmed Koch and Mies's observations in the rabbit, observing elevations of pressure between 120 and 190 Mm. of mercury; 80 per cent of the cases registered between 150 and 190 Mm. Dautrebande,⁶ in 1934, recorded three dogs with pressures of 190 to 220 Mm. of mercury, in his studies on the pharmacologic and chemical properties of the carotid sinus nerve.

A reconsideration of Koch's earlier work led him and his co-worker, Mattonet⁷ to recant his original claims of chronic duration of the hypertension obtained by carotid sinus and aortic-depressor denervation. Green, DeGroat and McDonald⁸ also reported essentially negative results after section of these afferent pathways.

The writer began this investigation, in 1934, on dogs, resorting to the Hering technic as modified by Heymans.[†]

METHOD.—Twenty dogs were studied. Ether or intravenous nembutal (0.5 cc. of 6 per cent solution [Abbott] per kilo) were used for anesthesia. In 13 of these dogs bilateral denervation was accomplished in one stage, according to the Hering-Heymans technic. This consisted of excising both common carotid bifurcations with the intervening plexus constituting the carotid sinus nerve and by resecting one to two centimeters of the aortic-depressor nerve in the vagal sheath (Fig. 1). In one dog, the effect of unilateral excision of the carotid bifurcation and aortic-depressor nerve was studied.

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† This technic, and the results of Heymans' investigation, were personally observed, in his laboratory in Ghent, by the author over a period of a year.

In three dogs, "pure denervation" was attempted by leaving the carotid bifurcation intact, resecting the carotid sinus plexus with careful removal of all macroscopic evidence of nerve structures including the adventitia in this region, and by excision of the aortic-depressor nerve in the neck as described above.

Damage to the internal carotid artery during this procedure, in one dog, necessitated excision of the bifurcation after pure denervation of the other side. This dog developed hypertension and was grouped with the first series.

The anemic effect of excising the carotid bifurcations and leaving the aortic-

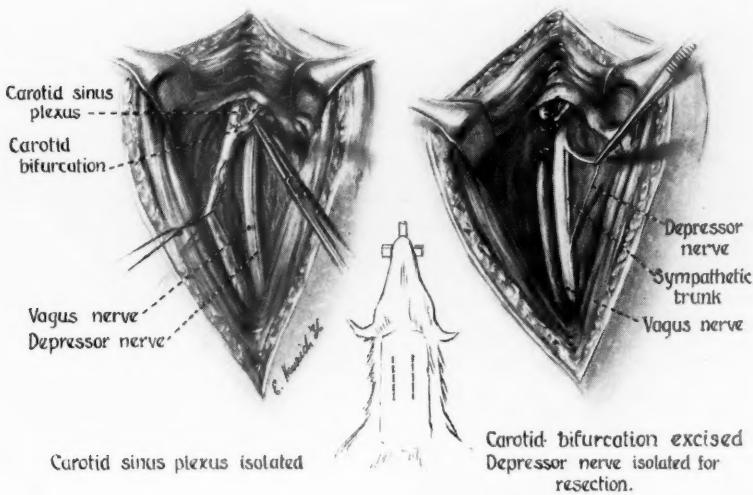


FIG. 1.—The Hering-Heymans method for carotid sinus exclusion and aortic-depressor nerve section.

depressor nerves intact was studied in one dog. It was further investigated by ligating the external and internal carotid arteries in two dogs. This procedure left the carotid sinus nerve plexus undisturbed.

Identification of the aortic-depressor nerve is unquestionably the most difficult part of the denervation. In some cases it stands out as a definite, fine white strand at the level of the carotid bifurcation lying within the vagal sheath in the groove between the cervical sympathetic trunk medially and the vagus trunk laterally (Fig. 1). In doubtful cases, Kreidman's⁹ method of identification of the nerve is very helpful. He observed that the nerve is formed by two or three fine strands at the junction of the superior laryngeal and vagus nerves which unite into a single strand and which continues its peripheral course as described above.

In several doubtful cases, stimulation of the cranial end of one of these strands was employed to observe cardiac slowing or hypotension but this test

could not be relied upon consistently. Its chief value lay in identifying the cervical sympathetic trunk which responds to stimulation by marked ipsilateral exophthalmos.

Blood pressure readings were accomplished by direct arterial puncture with a No. 19 or 20-gauge, intravenous needle with appropriate manometric connections for kymographic recording, 25 per cent magnesium sulphate being used as anticoagulant. The dogs were immobilized on their backs on an animal board and were observed for any unusual excitement during the process of blood pressure registration. In several cases the possible exciting effect of this procedure was studied by recording the heart rate by means of a modified Boas cardiotachometer before and during the blood pressure registration. Pressures were taken at about fortnightly intervals. One control blood pressure was usually taken, although in several dogs two to four readings were obtained when the initial pressure appeared unusually high. The dog's diet consisted of cooked meat, milk, bread and water. The animals were kept in cages and were exercised only by being allowed to run about the room once a day for a short time.

RESULTS.—Control Blood Pressure and Heart Rates in Dogs: In this series of dogs the predenervation blood pressures obtained by direct femoral arterial puncture varied from 100 to 162, averaging 130 Mm. of mercury. The heart rates ranged from 92 to 170, averaging 124.

Effect Upon the Heart Rate of Direct Puncture of the Femoral Artery for Blood Pressure Determination: The response of the heart rate to this procedure was used as an index of a possible exciting effect and consequently false hypertensive registration. In Dog 23, for example, the control heart rate as recorded by the Boas cardiotachometer was 115 per minute. Insertion of the needle into the artery caused absolutely no change in the heart rate while the blood pressure reading was 214 Mm. of mercury.

Criteria for Hypertension: While greater significance should be attached to relative changes in blood pressure, certain criteria are obviously necessary for gauging the results as a whole. On the basis of an average blood pressure of 130 Mm. of mercury, it was decided to establish 180 Mm. as a minimum hypertensive requisite. The required minimal duration was taken as six months. One dog (No. 15) was included with a hypertensive period of four and one-quarter months, however, because death occurred under an anesthetic prior to splanchnic section, after a consistently maintained average arterial tension of 213 Mm. of mercury.

Effect of Bilateral Carotid Bifurcation Excision and Aortic-Depressor Nerve Resection on Blood Pressure (Hering-Heymans Technic): Of the 13 dogs denervated by this method, seven developed definite chronic hypertension (Chart 1 and Table I). Four dogs showed only transient or no hypertension, and two died within four days after denervation.*

* Since submission of this article for publication three more dogs with hypertension have been added to this series, making a total of 10 chronic hypertensive dogs out of 16 attempts.

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Marked elevation of arterial pressure was observed as early as two days after this type of denervation. Thus Dog 9, whose control pressure was 124 prior to denervation, showed an increase to 184 two days later. In Dog 7, the pressure rose from a control level of 158 to 190 on the third day. In general, the blood pressure became definitely elevated within two to three

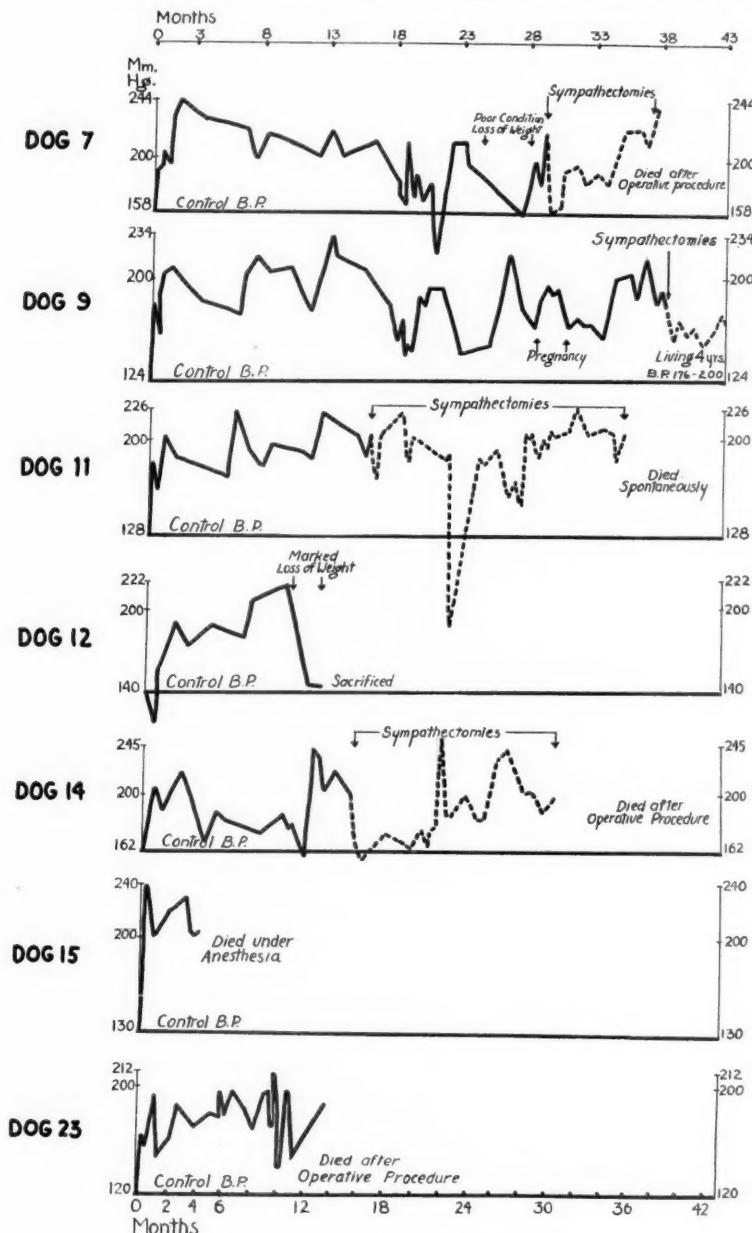


CHART 1.—Blood pressures in dogs with chronic hypertension produced by carotid sinus and aortic-depressor denervation. (Details of sympathetic procedures will appear in a subsequent communication.) Blood pressures brought up-to-date to show longevity of hypertension.

TABLE I
SUMMARY OF BLOOD PRESSURES AND HEART RATES IN DOGS WITH CHRONIC HYPERTENSION
PRODUCED BY CAROTID SINUS AND AORTIC-DEPRESSOR DENERVATION

Dog No.	Sex	Control B.P. and H.R.	Maximum B.P. Corresponding H.R.	Minimum B.P. Corresponding H.R.	Deter- minations	Per Cent B.P.		Duration of Hyper- tension in Months
						No.	Readings over 180 Mm.	
7	M.	B.P. 158 Mm. H.R. 155	B.P. 244 Mm. H.R. 174	B.P. 156 Mm. H.R. 150	52	67	B.P. 240 Mm. H.R. 96	38—Operative procedure fatal
9	F.	B.P. 124 Mm. H.R. 140	B.P. 234 Mm. H.R. 228	B.P. 140 Mm. H.R. 150	50	60	B.P. 190 Mm. H.R. 192	39—Living*
11	M.	B.P. 128 Mm. H.R. 170	B.P. 226 Mm. H.R. 222	B.P. 112 Mm. H.R. 136	53	74	B.P. 202 Mm. H.R. 146	36—Died spontaneously
12	F.	B.P. 140 Mm. H.R. 110	B.P. 222 Mm. H.R. 228	B.P. 114 Mm. H.R. 180	11	55	B.P. 146 Mm. H.R. 132	10—Sacrificed at 13 months. Condition poor. B.P. low
14	M.	B.P. 162 Mm. H.R. 136	B.P. 245 Mm. H.R. 156	B.P. 154 Mm. H.R. 138	38	68	B.P. 202 Mm. H.R. 150	30 $\frac{1}{4}$ —Operative procedure fatal
15	M.	B.P. 130 Mm. H.R. 96	B.P. 244 Mm. H.R. 216	B.P. 197 Mm. H.R. 186	7	100	B.P. 204 Mm. H.R. 186	4 $\frac{1}{4}$ —Died of anesthesia
23	M.	B.P. 120 Mm. H.R. 94	B.P. 212 Mm. H.R. 77	B.P. 142 Mm. H.R. 83	26	54	B.P. 190 Mm. H.R. 96	13 $\frac{1}{2}$ —Operative procedure fatal

* Died at 48 $\frac{1}{2}$ months after operative procedure, with final blood pressure of 186 Mm. Hg.

weeks after denervation. These findings are in agreement with those observed in the rabbit by Kremer, Wright and Scarff.⁵ The maximum reading obtained was 245 Mm. of mercury in Dog 14.

Effect of Unilateral Carotid Bifurcation Excision and Aortic-Depressor Nerve Resection on the Blood Pressure: Unilateral (left) excision of the carotid bifurcation and depressor nerve in the neck in one dog resulted in hypertension (210-190 Mm. of mercury) of seven and one-half months' duration, with return to about normal after this interval.

Fluctuations of Blood Pressure and Known Factors Associated with Such Fluctuations: Fluctuations in arterial tension were observed in the rabbit by Koch and Mies, and by Kremer, Wright and Scarff, and also in the dog by Heymans and Bouckaert.¹⁰ In Dogs 11 and 15, the blood pressure readings showed practically no fluctuations (Chart 1 and Table I). Known factors associated with fluctuations may be stated as follows:

(a) *Regeneration or Incomplete Denervation.* In two dogs, which failed to develop definite chronic hypertension after the Hering-Heymans operation, experiments were carried out to examine evidence of the aortic-depressor nerves due to regeneration or incomplete removal. The possible presence of the aortic-depressor nerves was determined by section of the vagi, below the

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region of resection and by cephalad faradic stimulation at this point. In one of these dogs (No. 19), bilateral vagotomy caused the blood pressure to rise temporarily from 150 to 216 Mm. of mercury, in another dog (No. 16), there was a slight rise from 114 to 140 Mm. In the latter dog there was evidence of a depressor reaction (118 to 74 Mm.) upon faradic stimulation of the left vagus.

(b) *Debility and Loss of Weight.* Dog 12 began to lose weight from severe cachexia 10 months after denervation. During the ensuing three months the blood pressure dropped to 146 after a persistent level of 182 to 222 Mm. of mercury. Recovery seemed unlikely and the dog was sacrificed.

Dog 7 also became cachectic 14 months after denervation with a drop to normal over a period of six months, after which, however, the blood pressure rose concomitantly with clinical improvement.

(c) *Pregnancy.* Dog 9 became pregnant 29 months after denervation. Prior to this time the blood pressure curve was quite variable with an upward trend before pregnancy so that the effect of the latter was difficult to evaluate. The blood pressure, however, rose further from 186 to 196 and dropped abruptly to 160, 10 days before termination of pregnancy (Chart 1). This part of the blood pressure readings can, in fact, be duplicated in other sections of the curve where spontaneous elevations and depressions were even more marked. The significant feature would appear to be absence of a striking hypertensive effect of pregnancy.

Duration of Hypertension: The shortest duration in this hypertensive series was four and one-quarter months (Dog No. 15), death occurring accidentally under anesthesia prior to an operative procedure. The longest survival was in Dog 9, with a hypertensive duration of three years and three months. (This dog is still alive after unilateral thoraco-abdominal sympathectomy with a final blood pressure of 200 Mm. of mercury, four years after denervation.)

Heart Rate: In general, denervation was followed by a marked and sustained augmentation of the heart rate. In practically all the dogs the acceleration varied almost directly with the blood pressure (Table I). In four dogs (Nos. 9, 11, 12 and 15) the maximum blood pressure readings showed correspondingly maximum heart rates. In three dogs (Nos. 7, 14 and 23) this relationship did not hold.

Dog 9 illustrates the parallelism with a maximum blood pressure of 234 Mm. of mercury and corresponding maximum heart rate of 228 per minute (Chart 2). Dog 7 shows the dissociation of these two factors with a blood pressure of 220 Mm. of mercury and heart rate of 130 per minute (Chart 2).

That adrenal secretion plays a definite rôle in the tachycardia in some of these animals, and a contributory rôle in others, was shown by diminution in the heart rate after bilateral adrenal inactivation or unilateral removal and contralateral inactivation. These findings will be discussed in detail in a subsequent communication.

Blood Counts, Cell Volume, Blood Gases, Blood and Urine Chemistry:

Blood counts, cell volume, oxygen and carbon dioxide content and capacity of the blood were within normal limits. Examination of carbohydrate, protein, fat, chloride and calcium content of the blood revealed no deviation from the normal. Urinalysis was also not remarkable except for a slight amount of sugar and moderate albumen.

Effect of Denervation of the Carotid Sinus Leaving the Bifurcation and Branches Intact with Excision of the Aortic-Depressor Nerve in the Neck—"Pure Denervation": This procedure was employed in three dogs, all of which failed to develop definite hypertension. Thus Dog 16, the control pressure of which was 117 Mm. of mercury, showed an increase of tension to 162 in two

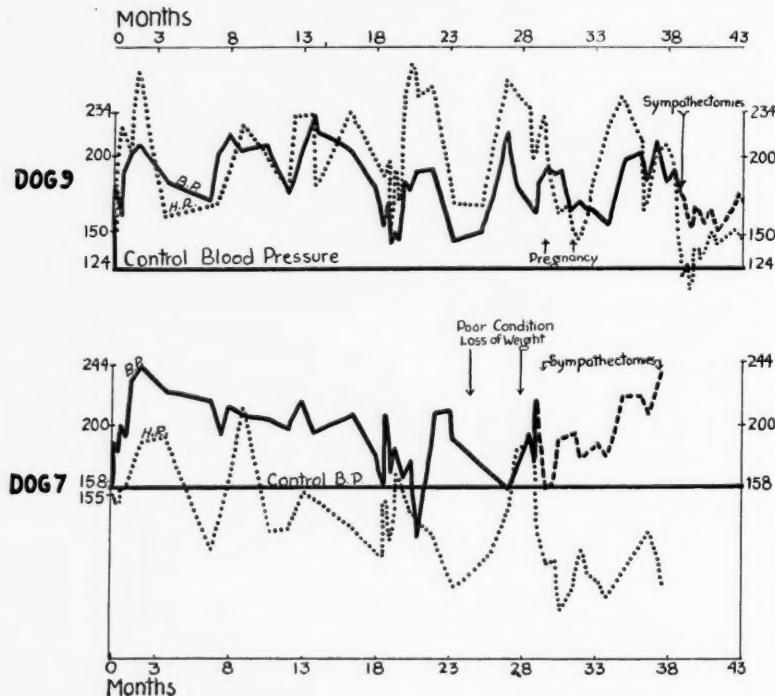


CHART 2.—Blood pressures and corresponding heart rates in dogs with chronic hypertension produced by carotid sinus and aortic-depressor denervation.

weeks followed by a drop to the control level and a later return to 154 Mm. of mercury two months after denervation. It is of interest that subsequent bilateral excision of the carotid bifurcations also failed to induce hypertension.

Dog 17, starting with a blood pressure of 146 Mm. of mercury, responded to pure denervation by a gradual rise to 172, four months after denervation, but returned to 143 Mm. eight months after denervation.

Dog 18 showed a rise from a control pressure of 144 Mm. of mercury to 166, three days after denervation and a decline to 154 Mm. at the end of one month. Excision of both carotid bifurcations subsequently failed to produce hypertension.

Effect upon Blood Pressure of Excision of the Carotid Bifurcation and of

Ligation of the Branches of the Carotid Bifurcation: In Dog 19, the control blood pressure of which was 116 Mm. of mercury, the carotid bifurcations were excised in one stage. The maximum pressure observed after this procedure was 146 Mm. of mercury six weeks later. Seven and one-half months later it was 108 Mm. of mercury. It is of interest that bilateral depressor nerve section at this time also failed to produce hypertension. The highest pressure recorded was 144 Mm. of mercury, six weeks after this section.

In two dogs, the branches of the carotid bifurcation were ligated. The results in these dogs were as follows: In Dog 20 the blood pressure rose sharply from a control level of 150 to 197 Mm. of mercury in the first week, after which it showed variations and a gradual return to 158 Mm. of mercury in four months. Dog 29 showed a rise from a control pressure of 142 to 179 Mm. of mercury; this level has been maintained to date over a period of three and one-half months. Thus the anemic effect of exclusion of the carotid bifurcation or its branches with respect to the blood pressure response is a variable one. When the effect is hypertensive it was not permanent except in one dog which was only recently operated upon.

DISCUSSION.—The recantation of Koch,⁷ and the negative results of Green, DeGroat and McDonald⁸ have raised serious doubts as to the accuracy of the findings of the workers who have reported chronic hypertension by carotid sinus and aortic-depressor denervation.

Examination of Koch and Mattonet's⁷ results on four dogs, all of which failed to maintain their original hypertension, shows that at least two manifested evidence of depressor nerve activity by a rise in pressure (125 to 185 Mm.) after bilateral vagotomy in the terminal experiment. The other two dogs showed slight rises in pressure after the same procedure. In the face of these indications of incomplete denervation or regeneration, their work cannot be considered conclusive.

The possibility of incomplete denervation or regeneration might also be considered in the technic employed by Green, DeGroat and McDonald.⁸ In order to assure complete chronic denervation of the carotid sinus nerve, excision of either arterial branch of the carotid bifurcation or the bifurcation itself has been practiced by most workers. The technic of Green and his co-workers leaves the bifurcation and its branches intact. Employing a similar technic, referred to above as "pure denervation," the writer was unable to produce definite hypertension in three dogs, and in this respect is in agreement with these workers but failure to obtain hypertension was ascribed to incomplete denervation. Our control experiments on the anemic effect of carotid bifurcation excision and of ligation of the branches of the bifurcation, although variable, appeared to rule out anemia as a factor in this hypertension. It is impossible to say, however, whether this degree of anemia might not sensitize the effect of carotid sinus and aortic-depressor denervation.

On the other hand, terminal studies carried out in two of our four failures, operated upon by the Hering-Heymans' technic, showed evidence of some

degree of depressor nerve response upon stimulating the cranial end of the cut vagus nerve. It cannot be stated that the amount of depressor activity observed was sufficient to account for the lack of hypertension. It is conceivable that other afferent pathways were operating in these dogs to neutralize the hypertensive effect of the denervation.

Fluctuations in blood pressure readings have already been described by previous workers. In three of the seven hypertensive dogs the fluctuations were marked, reaching normal values frequently over a period of weeks. As discussed in the results, inanition was undoubtedly the cause of this remission in two dogs, while in the third no apparent cause could be found. In two of these dogs hypertension was reestablished. Insistence on a sustained high arterial tension, although met with in two of our dogs, is an exacting demand in the light of clinical hypertensive experience.

The absence of abnormal chemical changes in the blood carbohydrate, protein, fat, chloride, calcium, oxygen and carbon dioxide argues against the possibility of chemohumoral basis for the hypertension produced by this method. The lack of disturbance in the cell volume rules out blood viscosity as a factor. On the other hand the investigations of Hering,¹ Koch and Mies,² Heymans and Bouckaert,¹¹ and Nowak¹² show that the hypertension resulting from carotid sinus and aortic-depressor denervation is chiefly neuroconstrictive.

SUMMARY

- (1) Chronic hypertension was produced in ten dogs by carotid bifurcation excision and cervical aortic-depressor nerve resection.
- (2) The maximum duration of hypertension was three years and four months.
- (3) Fluctuations in arterial tension were observed in the majority of these dogs. Inanition was definitely responsible for marked remission of hypertension in two dogs.
- (4) Failure to produce chronic hypertension by this method occurred in four dogs. In two of these animals, in which terminal experiments were carried out, there was evidence of some degree of aortic-depressor nerve activity.
- (5) The anemic effect of excising the carotid bifurcations are discussed.
- (6) "Pure denervation," preserving the vessels of the carotid bifurcation, failed to produce lasting hypertension in three dogs.
- (7) Unilateral (left) denervation produced hypertension in one dog of seven and one-half months' duration, with final return to normal level.
- (8) Pregnancy did not alter appreciably the course of hypertension in one dog.
- (9) Persistent tachycardia was a common finding after denervation. Its degree varied directly with the blood pressure readings in most instances. Maximum blood pressure readings were correlated with maximum heart rates in about one-half the cases.

(10) There were no changes in the blood carbohydrates, proteins, fats, chlorides, calcium, oxygen, carbon dioxide, cell volume and red cell counts.

(11) Urinalyses were also essentially normal.

BIBLIOGRAPHY

¹ Hering, H. E.: Die Karotissinusreflexe auf Herz und Gefäße vom normal-physiologischen, pathologisch-physiologischen und klinischen standpunkt. Dresden, Th. Steinkopff, 1927.

² Koch, E., and Mies, H.: Krankheitsforschung, **7**, 241, 1929.

³ Koch, E.: Ergebnisse der Kreislaufforschung. Band I, Th. Steinkopff, Dresden, 1931.

⁴ Heymans, C., and Bouckaert, J. J.: Compt. rend. Soc. de biol., **106**, 471, 1931.

⁵ Kremer, M., Wright, S., and Scarff, R. W.: Brit. Jour. Exper. Path., **14**, 281, 1933.

⁶ Dautrebande, L.: Calif. and West. Med., **40**, 145, 1934.

⁷ Koch, E., and Mattonet, K.: Ztschr. f. d. ges. exper. med., **94**, 105, 1934.

⁸ Green, M. F., DeGroat, A. F., and McDonald, C. H.: Am. Jour. Physiol., **110**, 513, 1935.

⁹ Kreidman, A.: Archiv. f. Anat. u. Physiol., **1**, 405, 1878.

¹⁰ Heymans, C., and Bouckaert, J. J.: Bull. Acad. Roy. Mèd. Belg., **1**, 42, 1936.

¹¹ Heymans, C., and Bouckaert, J. J.: Arch. internat. de pharmacodyn. et de thérap., **48**, 191, 1934.

¹² Nowak, S. J. G.: Compt. rend. Soc. de biol., **115**, 1731, 1934.
Idem: Arch. internat. de pharmacodyn. et de thérap., **60**, 129, 1938.

PHEOCHROMOCYTOMA

CASE REPORT

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WE have been accustomed to think of tumors as being either malignant or benign, the chief points of differentiation being based upon the question of the spread of the tumor through distant metastases or by the extension to contiguous structures. This differentiation, obviously, is based upon anatomic considerations. From this point of view, one would be forced to consider the pheochromocytomata benign tumors. Interestingly enough, several very recent text-books describe this tumor type as "a rare tumor which is innocent, small, well encapsulated, and may be found by accident at autopsy in elderly persons."

An increasing number of case reports within the last few years have demonstrated, conclusively, that this tumor type is not the "innocent" tumor it was thought to be. The hypertension which many writers have described as being an incidental finding in such cases has been proven to be due to the tumor. These pheochromocytomata characteristically produce attacks of elevated blood pressure, paroxysmal in nature. The paroxysmal hypertension acting over a period of time results in the arteriolar sclerosis which ultimately results in death to the patient.

For this reason we prefer to consider this type of tumor as benign anatomic but malignant physiologically. It is the physiologic activity of this tumor that is malignant and not its anatomic consideration. Being composed of adrenal medullary tissue, the attacks of paroxysmal hypertension are generally conceded as being due to the temporarily increased output of epinephrine. The symptoms associated with the attacks of hypertension are those commonly found as a result of an overdose of epinephrine; namely, palpitation, cold clammy extremities, pallor, nervousness and dizziness. Because of the infinitesimally small amount of epinephrine normally found in the circulating blood (1 to 100,000,000),¹ it is apparent that attempts to measure this increase have been unsuccessful. Kalk² has demonstrated, however, 375 mg. to 500 mg. of epinephrine in a tumor of this type, whereas the normal adrenal is said to contain only 4.22 mg. of epinephrine.

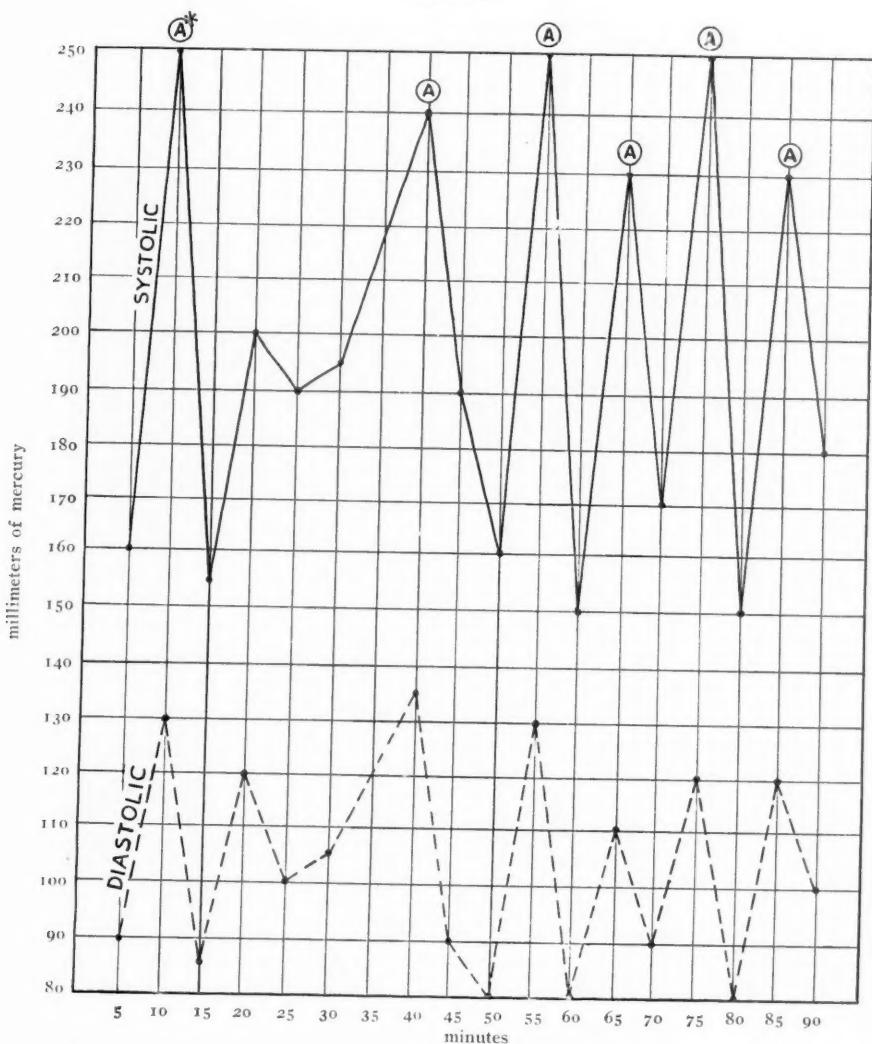
From what has been said, it becomes apparent that many of the cases of the so-called "essential hypertension," which in the early stages are described as having paroxysmal elevations of blood pressure, may very likely be due to

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chromaffinomata. Certainly, it is the duty of the surgeon to investigate this carefully in the 20- to 40-year-old group, with a view to recognizing cases of this type of tumor and removing them before irreparable damage is done to the cardiovascular system as a result of the hypertension. It is in this age

CHART 1



* At points "A" dizziness, cold, clammy extremities, tremor, and pallor occurred.

group that the results of surgery are indeed brilliant. Coller³ reports the case of a male, age 25, with the pathognomonic fluctuations of blood pressure, in whom the classic tumor was found at operation. A complete cure resulted, and a normal future was substituted for one of impending death due to damaged vessels in the heart, kidneys or brain. The opposite side of the picture is presented in our case report which shows the end-results of this type of

tumor, which was permitted to remain until the cardiovascular system was so extensively damaged that a cure was impossible.

Case Report.—H. P., white, adult male, was first seen by one of us (E. C. B.) July 9, 1928. At this time he complained of tiredness and headaches. These had been rather troublesome during the past three years, but not to such a degree as to interfere with his work. With these attacks of headache he would complain of dizziness, cold sensations, "goose-flesh," and nervousness. There was no nausea or vomiting associated with the headaches which were diffuse over the entire cranium. No blurring of vision or spots before eyes. No ataxia. His appetite was good.

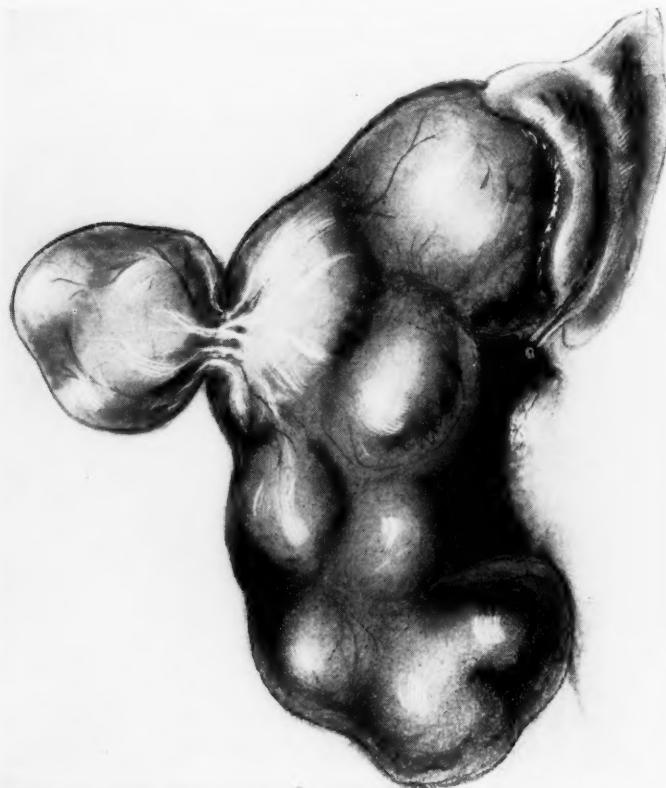


FIG. 1.—Drawing showing the position of the adrenal medullary tumor springing from the loose tissue over the convex border of the right hydronephrotic kidney. It was not attached to the kidney directly.

Physical Examination.—The only deviation from the normal was a systolic blood pressure of 160 and a diastolic of 100 Mm. of mercury. His urine on this occasion was negative for albumin and signs of kidney damage. Kahn test was negative.

He was advised to return to the office at monthly intervals for a check-up of his blood pressure. During the next six years his blood pressure was found to fluctuate between 250 and 130 Mm. mercury systolic and 130 to 90 Mm. mercury diastolic. During the periods of high blood pressure he would complain of nervousness, coldness, and dizziness. In the intervals between attacks his blood pressure would range from 130 to 145 Mm. mercury systolic and 80 to 90 Mm. mercury diastolic. The most interesting feature of these attacks was the suddenness of onset and the marked fluctuations during the interval of 90 minutes. On many such occasions we would leave the sphygmomanometer

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cuff on his arm and take blood pressure readings at five-minute intervals. We would then find the blood pressure to rise from 145/90 to 250/130 many times during an hour's time (Chart 1).

The patient continued then, from 1928 to 1937, with these periodic attacks of paroxysmal hypertension and the associated dizziness, nervousness, and headaches until January 3, 1937. On this date, while sitting, he was suddenly seized with a very severe pain in the left chest. This was so severe that he was unable to move. It was sharp and shooting in character and radiated to the left back and down the left arm. It was of three minutes' duration and was accompanied by a marked fear of impending death. He was admitted to the Evangelical Deaconess Hospital, with a diagnosis of coronary occlusion. This diagnosis was verified electrocardiographically. Death occurred suddenly on his sixth hospital day.

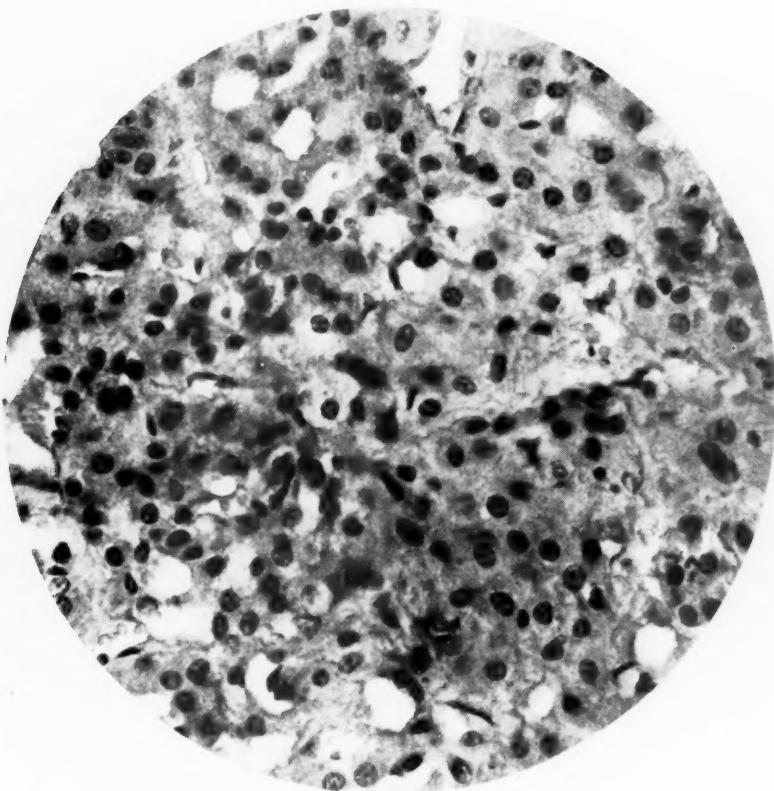


FIG. 2.—Section taken from tumor attached to convex border of kidney. (X950)

Autopsy.—The pertinent findings were: Heart enlarged, but not markedly. Complete occlusion of the descending branch of the left coronary artery. Necrosis of the interventricular septum. Coronary sclerosis.

A walnut-sized tumor mass was found attached to the loose areolar tissue over the convex, lateral surface of the right kidney about midway between its poles (Fig. 1). It was firm, and derived its blood supply from the areolar tissue it was imbedded in and not from the kidney. On section, a soft pale yellowish surface was seen.

Microscopic examination of tumor revealed the anastomosing cords of very deep staining epithelial cells separated by numerous thin-walled sinusoids. Many of the cells appear to be multinucleated (Fig. 2). *Pathologic Diagnosis*.—Adrenal medullary tissue—chromaffinoma (Dr. P. F. Morse).

COMMENT.—This case presents the typical course taken by a patient with a chromaffinoma (pheochromocytoma). During its early stages, we find the pathognomonic attacks of paroxysmal hypertension with the associated symptoms of dizziness, pallor, nervousness, and cold clammy extremities, which are generally conceded as being due to hyperepinephrinemia. Then, later in life, we find the arteriolar sclerosis which is the result of the unchecked hypertension. In this particular individual the small vessel sclerosis showed a marked predilection for the coronary arteries, with a resultant typical coronary occlusion—and death. The cardiac, neurologic, and renal consequences of the hypertension are the same in all types of continued high blood pressure regardless of cause. When these changes have become marked, treatment is hopeless. The time to attack this problem is at the beginning when the paroxysmal attacks of high blood pressure first make their appearance. It is these attacks that are pathognomonic of a pheochromocytoma.

It is important to remember that since the tumor may appear on the right or left side, consequently, if at operation over the right adrenal no tumor is found, the left adrenal area should then be explored.

CONCLUSIONS

- (1) This case presented the typical picture of a pheochromocytoma which was permitted to run its course without interference.
- (2) This course is: Paroxysmal attacks of hypertension, then, as a result of the continued high blood pressure, the cardiac, neurologic, or renal consequences become manifest due to the small vessel sclerosis. The typical coronary occlusion was the mode of exodus in this case.
- (3) Diagnosis may be made solely upon the pathognomonic attacks of the paroxysmal hypertension.

REFERENCES

- ¹ Barr, P. D.: Recent Advances in Endocrinology. *J.A.M.A.*, **105**, 1760, November 30, 1937.
- ² Kalk, H.: Paroxysmale Hypertension. *Klin. Wchnschr.*, **13**, 613, April 28, 1934.
- ³ Coller, F. A., Field, H., and Durant, T. M.: Chromaffin Cell Tumor Causing Paroxysmal Hypertension. *Arch. Surg.*, **28**, 1136, June, 1934.

A MODIFIED FORM OF LUMBAR SYMPATECTOMY FOR DENERVATING THE BLOOD VESSELS OF THE LEG AND FOOT; ANATOMIC CONSIDERATIONS

A PRELIMINARY REPORT

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J. C. WHITE^{1, 2} has recently propounded the hypothesis that the therapeutic value, in cases of arterial disease of the lower extremity, of removing the second, third, and fourth lumbar ganglia depends to a great extent on leaving the sacral ganglia intact. Ascroft's³ work lends weight to this hypothesis. By removing the sacral ganglia, he has been able to destroy the beneficial effects of a previously satisfactory lumbar sympathectomy. This work was carried out on monkeys. By virtue of leaving the sacral ganglia undisturbed, a predominantly preganglionic denervation of the blood vessels of the foot is obtained. In this manner, the sensitization of arteriolar musculature to circulating adrenaline which follows destruction of its postganglionic innervation^{4, 5, 6, 7, 8, 9, 10} is avoided, and the denervated arterioles in the foot remain dilated. It occurred to me that removing the lumbar ganglia might be an entirely superfluous procedure, and that it might be possible to achieve the desired therapeutic result, in properly selected cases, by merely sectioning the lumbar sympathetic trunk at an appropriate level.

Figure 1 indicates diagrammatically the way in which the sympathetic vasomotor and sudomotor fibers are supposed to reach the lumbosacral plexus,^{1, 11} within the branches of which they are distributed to the blood vessels and sweat glands, respectively, of the lower extremity.¹² The diagram and its legend are self-explanatory. However, there are several points to which I should like to draw particular attention:

- (1) There are four lumbar ganglia and not five.
- (2) This reduction in number is theoretically brought about by the fusion of the ganglia sending gray rami to the fourth and fifth lumbar spinal nerves.
- (3) Interruption of the trunk between the third and fourth lumbar ganglia, as indicated at (a) in Figure 1, should theoretically destroy all preganglionic neurones forming synapses with postganglionic neurones to spinal nerves L. 4, 5; S. 1, 2, and 3. In this manner, the blood vessels and sweat glands receiving their postganglionic sympathetic innervation through these spinal nerves would be denervated; and the denervation would be entirely preganglionic.

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The blood vessels thus denervated would be the popliteal artery and its branches through the sciatic nerve, and the cutaneous vessels of the foot and leg through L. 4, 5; S. 1, 2. It was felt that since the extent of such a denervation would be quite adequate for the treatment of a large number of cases of arterial disease involving the lower extremity, a lumbar sympathectomy modified in this manner would be of value for two reasons:

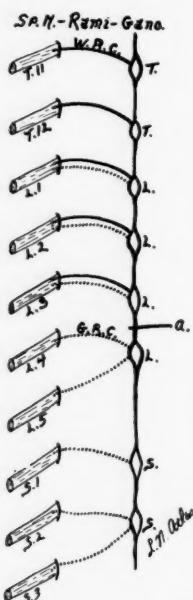


FIG. 1.—W. R. C.: Preganglionic neurones from T. 11, 12; L. 1, 2, and 3 carrying vasoconstrictor and sudomotor impulses, and form synapses with G. R. C.: Postganglionic neurones which are distributed to blood vessels of lower extremity via L. 1, 2, 3, 4, 5; S. 1, 2, and 3. Sp. N.: Spinal nerves. Rami: Rami communicantes. Gang.: Sympathetic ganglionated trunk. T.: Thoracic; L.: Lumbar; S.: Sacral. (a) Shows point at which trunk was divided in first operation; see text and Figure 2. (Based on information drawn from White,¹ and Gask and Ross,¹¹ and Potts.¹²)

Accordingly, it was decided to attempt such a denervation in the following case, by dividing the lumbar sympathetic trunk at the upper pole of the fourth lumbar ganglion, treating the divided ends to prevent regeneration, and leaving the ganglia themselves undisturbed.

Case Report.—Hosp. No. 186118: A. C., white female, age 31, was referred to the Peripheral Vascular Clinic of the Cleveland City Hospital from the Lowman Pavilion, where she is being treated for pulmonary tuberculosis. Fourteen years previously, her fingers started to turn blue and white on exposure to cold or during emotional upsets, and she would perspire profusely. Seven years later, a severe atrophic arthritis developed in her fingers, resulting in extreme deformity. Five years ago, she noticed that her feet would also become cyanotic on exposure to cold or during emotional upsets, accompanied by increased perspiration. Recently, an atrophic type of arthritis had started to involve her toes.

Physical Examination.—The patient was very apprehensive and nervous. Her hands and feet were markedly cyanotic, covered with perspiration and cold to the touch. Both hands were markedly deformed. There was also an early arthritis deformans involving several of the toes. Pulsation in the dorsalis pedis and posterior tibial arteries was palpable. Under a spinal anesthetic, and at a room temperature of 23° C., skin temperatures, taken from various points on the feet, rose from 21.0°–23.5° to 33.2°–34.2° C. In view of the possible connection between the obvious vasospasm and the subsequent development of the arthritic process, it was decided to abolish the vasospasm in the feet by means of a lumbar sympathectomy, hoping, thereby, to arrest the progression of the joint disease.

Operation.—Through a right-sided, muscle splitting retroperitoneal approach, described by Pearl,¹³ the fourth lumbar ganglion was located. The sympathetic trunk was divided at the upper pole of the ganglion, both ends were ligated with silk, and the

proximal end buried in the adjacent psoas muscle. As anticipated, the operation was easily and quickly performed.

Subsequent Course.—The next day the patient presented a very interesting picture. The right inferior extremity below the knee was hot and dry to the touch with the exception of a patch of skin around the internal malleolus which extended down the inner border of the foot. This patch was cold and covered with sweat.

A week later, the left lumbar sympathetic trunk was similarly severed at the upper pole of the fourth lumbar ganglion. The next day, the patient presented the same picture as existed on the right except the extent of the undenervated zone was even more striking and could be easily mapped out (Fig. 2). It is seen to embrace the cutaneous distribution of the terminal fibers of the saphenous nerve. Segmentally, this zone is L. 4.

Unable to account for the fact that the vasomotor and sudomotor fibers distributed through the fourth lumbar nerve had been left intact, provided the schema as portrayed in Figure 1 was anatomically correct, I was led to reexamine the manner in which the lumbar ganglia are connected with the lumbar spinal nerves.

Anatomic Research.—For the purpose of the study, 31 lumbar sympathetic trunks were dissected in the Anatomical Laboratory of Western Reserve University. Since the dissections were gross, it is possible that in some instances very fine rami were not defined. However, I am confident that all the major communications and the important accessory ones were found.

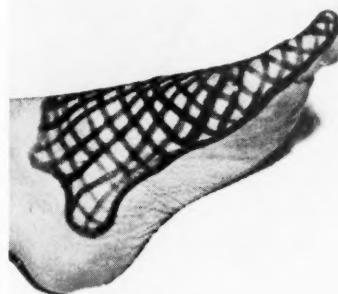


FIG. 2.—Cross-hatching shows extent of undenervated region remaining after division of lumbar sympathetic trunk at point (a) in Figure 1. Note similarity to zone of distribution of saphenous nerve in foot which is L. 4 segmentally.

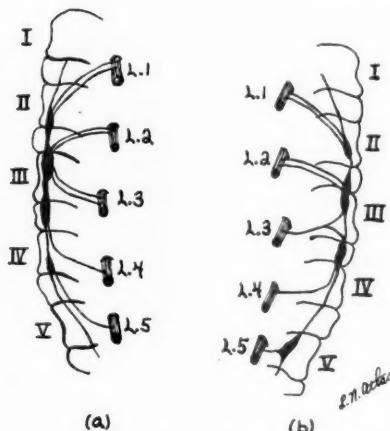


FIG. 3.—Two variations in topographic anatomy of the lumbar sympathetic ganglia and their connections with the lumbar spinal nerves. (Drawn from original dissections in Anatomical Laboratory of Western Reserve University.)

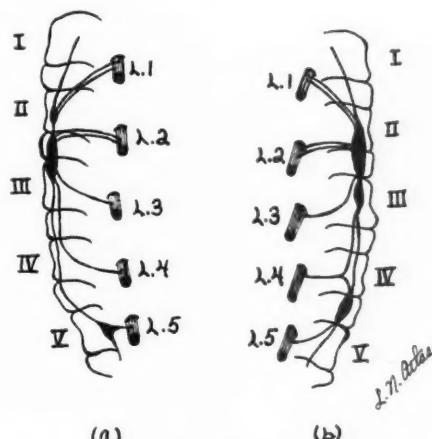


FIG. 4.—Two variations in topographic anatomy of the lumbar sympathetic ganglia and their connections with the lumbar spinal nerves. (Drawn from original dissections in Anatomical Laboratory of Western Reserve University.)

There were no instances, save one, in which more than four lumbar ganglia were present. In the exception, there were five, due to a reduplication of the ganglion connected with the fourth lumbar nerve (Fig. 5 b). However, there were many instances in which further fusion had reduced the number to three. The nature of these fusions will be discussed in detail below.

The first lumbar nerve was constantly connected with the highest lumbar ganglion by two major rami (Figs. 3b, 4a, and 5a). This ganglion rested on the second lumbar vertebra and was occasionally overlapped by the intermediate crus of the diaphragm. Its connections with the first lumbar nerve left the ganglion in a cephalad direction. At times it was incompletely fused (Fig. 3a), or completely fused (Fig. 4b), with the proximal pole of the ganglion just distal to it, namely, that connected with the second and third lumbar nerves.

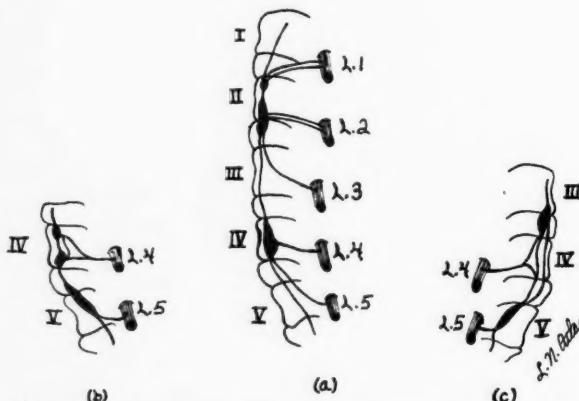


FIG. 5.—Three variations in topographic anatomy of the lumbar sympathetic ganglia and their connections with the lumbar spinal nerves. (Drawn from original dissections in Anatomical Laboratory of Western Reserve University.)

The second and third lumbar nerves had their major connections in every instance with a *single* ganglion (Figs. 3, 4, and 5a). The second nerve was connected by two major rami which usually made their exit from the ganglion in a cephalad direction. The third nerve was connected by a single major ramus which usually left the ganglion in a caudad direction. It was often joined by an accessory branch from the ganglion connected with the fourth lumbar nerve (Fig. 3b). Only once was the third nerve connected by two major rami. The position of the ganglion was fairly constant. It rested at the edge of the psoas muscle on the second lumbar intervertebral disk and the bodies of the vertebrae (L. 2 and 3) adjacent to it. It was consistently the largest of all the ganglia. The ganglia connected with the first and fourth lumbar nerves were at times partially or completely fused with its upper and lower poles, respectively.

The connections of the fourth lumbar nerve were variable. In 16 instances it was connected with a distinct ganglion having no major connections with any of the other lumbar nerves (Fig. 3a). In one of these instances the

ganglion was split (Fig. 5b). In 12 instances the fourth nerve was connected with a ganglion which was either partially fused (Figs. 3a and 4b), or completely fused (Fig. 4a), with the lower pole of the ganglion connected with the second and third lumbar nerves. In only three instances was it fused with the ganglion connected with the fifth lumbar nerve (Fig. 5a). The connection with the fourth lumbar nerve consisted of a single major ramus, which usually left the ganglion in a caudal direction, and which was on several occasions joined by an accessory branch from the ganglion connected with the fifth lumbar nerve (Figs. 4b and 5c). Lying at the edge of the psoas major muscle, the position of the ganglion was otherwise variable. In 12 instances it was located on the third lumbar vertebra, in 14, on the third lumbar intervertebral disk, and in five, on the fourth lumbar vertebra. When on the third lumbar vertebra, it was partially or completely fused with the lower pole of the ganglion connected with the second and third lumbar nerves in every instance save one. When on the third lumbar intervertebral disk, it was separate and distinct in every instance except one. When on the fourth lumbar vertebra, it was separate and distinct in two instances and fused with the ganglion connected with the fifth lumbar nerve in three.

The fifth lumbar nerve was connected by a single major ramus to the most distal of the lumbar ganglia. In 21 instances, this ganglion had no connection with any other lumbar nerve (Figs. 3a and b, 4a and 5b). In seven instances, it sent an accessory branch cephalad to join the major ramus to the fourth lumbar nerve (Figs. 4b and 5c). In only three instances were the fifth and fourth lumbar nerves connected with the same ganglion (Fig. 5a), which, in every instance, was located on the fourth lumbar vertebra at the edge of the psoas muscle. In one other instance, the ganglion was located on the fourth lumbar vertebra, in six, on the fourth lumbar intervertebral disk, and in 21, on the fifth lumbar vertebra. When on the last lumbar vertebra, it was often completely overlapped by the psoas major muscle, covered by a dense layer of fascia, and in close proximity to the fifth lumbar nerve. I am convinced that in a large number of lumbar ganglionectomies, the fourth ganglion is never seen, and that what is considered to be the last is really the third.

One of the results of this study is that certain concepts concerning the topographic anatomy of the lumbar sympathetic ganglia and their connections with the lumbar spinal nerves must be revised. The requisite changes are portrayed diagrammatically in Figure 6. The diagram and its legend are self-explanatory.

In addition, it was evident that severing the lumbar sympathetic trunk on the body of the *third* lumbar vertebra would accomplish one of two things, depending on the anatomic disposition of the ganglia:

- (1) If the ganglion connected with the fourth lumbar nerve is separate and distinct, all the preganglionic fibers to blood vessels innervated through L. 4, 5; S. 1, 2, and 3 would be destroyed. The point of division is at (a) in Figure 6.

(2) If there is a fusion of the ganglia connected with L. 2, 3, 4, then the postganglionic fibers to blood vessels innervated through L. 4, and the preganglionic fibers to the blood vessels innervated through L. 5, S. 1, 2, and 3 would be destroyed. The point of division is at (b) in Figure 6.

Either way, the undenervated area corresponding to the segmental cutaneous innervation from L. 4, encountered in the reported case, would be avoided. In addition, it has been my experience that exposing the trunk on the third lumbar vertebra often reveals the accessory connection of the trunk with the third lumbar spinal nerve. These can also be divided giving an absolutely complete denervation of all the blood vessels below the thigh.

The question arises whether a lumbar sympathectomy modified in this manner, that is, by dividing the lumbar sympathetic trunk on the body of the third lumbar vertebra, dividing its accessory connection with the third lumbar spinal nerve, and managing the divided ends to prevent regeneration, would have any appreciable advantage over the usual ganglionectomy. I believe it will prove to be of value as an alternative procedure to be used:

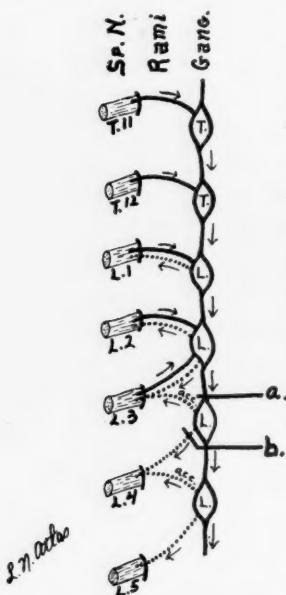


FIG. 6.—Diagrammatic schema of connections of the lumbar spinal nerves with the lumbar sympathetic ganglia based on dissection of 31 lumbar sympathetic trunks. Note changes from Figure 1. Note constant fusion of ganglia connected with L. 2 and 3 to reduce the number of lumbar ganglia to four. Further fusion, as described in the text, may reduce total number of lumbar ganglia to three.

Acc.: Accessory postganglionic ramus.

Arrows indicate flow of vasoconstrictor and sudomotor impulses. This flow may be interrupted at either (a) or (b) by dividing the trunk on the body of the third lumbar vertebra.

(1) When the risk of producing sexual disturbances from a bilateral denervation must be reduced to a minimum.

(2) When technical difficulties encountered at the time of operation render exposure of the ganglion connected with the second and third lumbar spinal nerves so difficult as to render an attempt to remove it inadvisable. Difficulty in exposing this ganglion is not infrequently encountered in obese individuals, and in instances of inadequate relaxation from a poorly administered anesthetic. Reference to Figure 6 will indicate why the removal of the ganglion connected with the second and third lumbar spinal nerves, and only this ganglion, is necessary if all the vessels in a lower extremity are to be denervated. In fact, unless

this ganglion is removed, resection of the more distal ones can accomplish no more than merely division of the trunk on the third lumbar vertebra without disturbing any of the ganglia.

(3) On poor surgical risks or elderly individuals where operative manipulation is to be kept at a minimum.

(4) When a denervation limited to the blood vessels of the foot and leg will suffice.

Up to the present time, I have found occasion to employ this modified form of lumbar sympathectomy in 27 instances. In every case, the extent of the denervation obtained was equal to that anticipated. In some of the earlier cases, where the accessory connection of the trunk with the third lumbar spinal nerve was overlooked, only partial denervation of the cutaneous vessels

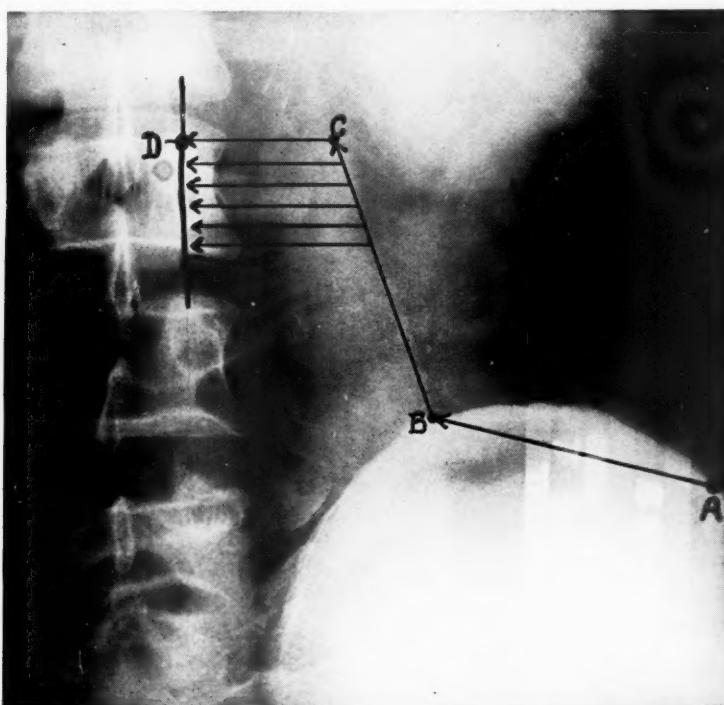


FIG. 7.—Illustrates the technic employed to expose the lumbar sympathetic trunk on the body of the third lumbar vertebra through a muscle splitting retroperitoneal approach.

in the upper half of the leg was obtained. This was probably due to an overlapping of segmental cutaneous innervation from L. 3. A bilateral operation in a male, age 42, did not produce any disturbance of sexual function. Some of these individuals have been observed for over a year, and in none has any diminution in the extent or magnitude of the denervation, which could be attributed to regeneration been encountered.

Operative Technic.—The following technic is employed to expose the lumbar sympathetic trunk on the third lumbar vertebra. A roentgenogram is made before the operation, in order to show the relationship of the crest of the ilium, the lateral margin of the psoas major muscle, and the third lumbar vertebra. The muscle splitting retroperitoneal approach described by Pearl is preferred, using 150 mg. of novocain intrathecally as the anesthetic. This

approach is quickly and easily performed, it is remarkably free from shock or postoperative reaction, and gives excellent exposure of the third lumbar vertebra. When the retroperitoneal space is opened, the crest of the ilium is immediately palpated; at point A in Figure 7. The retroperitoneal tissues are dissected from the crest of the ilium until the lateral edge of the psoas major



FIG. 8.—Roentgenogram taken on seventh postoperative day showing silver clips on cut ends of sympathetic trunk. Clip opposite fifth lumbar vertebra is point at which distal end is buried in psoas muscle. Clip on third lumbar vertebra is point of division. Included in this clip is divided accessory ramus to third lumbar nerve at point where ramus dips backward between vertebra and psoas muscle.

muscle is reached at the point where it crosses the crest; at point B in Figure 7. The lateral edge of this muscle is then exposed in a cephalad direction until a point is reached opposite the upper border of the third lumbar vertebra; at point C in Figure 7. The magnitude of this cephalad dissection is equal to the length of line B-C. Further dissection carried medially over the psoas muscle will now expose that portion of the lumbar sympathetic trunk lying on the body of the third lumbar vertebra. The trunk and any accessory parallel

fibers are divided between silk ligatures at the upper limit of the dissection; at point D in Figure 7. The distal portion is then dissected off the body of the third lumbar vertebra. During this stripping process, the accessory connection with the third lumbar nerve is usually broken. The distal cut end is then buried in the adjacent psoas muscle; at point E in Figure 7. The retractors are removed and the patient is instructed to cough. This balloons the peritoneum, obliterating all dead space, and approximates the split muscular layers. The incision is closed in the usual manner. By placing silver clips on the cut ends of the trunk, it is possible to determine by a postoperative roentgenogram at what point the trunk was divided and the point at which the distal end was buried in the psoas muscle. This is illustrated in Figure 8. Note that the distance separating the cut ends is actually much greater than that shown in Figure 7, the latter being purely diagrammatic for purposes of illustrating technic.

REFERENCES

- ¹ White, J. C.: The Autonomic Nervous System. Macmillan, New York, 1935.
- ² White, J. C.: Progress in Surgery of Autonomic Nervous System. *Surgery*, **4**, 781, November, 1938.
- ³ Ascroft, P. B.: The Basis of Treatment of Vasospastic States of the Extremities: An Experimental Analysis of Monkeys. *Brit. Jour. Surg.*, **24**, 787, 1937.
- ⁴ Meltzer, S. J., and Auer, C. M.: Studies on the "Paradoxical" Pupil Dilatation Caused by Adrenalin. *Amer. Jour. Physiol.*, **11**, 28, 1904.
- ⁵ Freeman, N. E., Smithwick, R. H., and White, J. C.: Reactions of Blood Vessels of Human Extremity Sensitized by Sympathectomy to Adrenalin. *Amer. Jour. Physiol.*, **107**, 529, 1934.
- ⁶ Smithwick, R. H., Freeman, N. E., and White, J. C.: Effect of Epinephrine on Sympathectomized Extremity. *Arch. Surg.*, **29**, 759, 1934.
- ⁷ Grant, R. T.: Further Observations on the Vessels and Nerves of the Rabbit's Ear, with Special Reference to the Effects of Denervation. *Clin. Sci.*, **2**, 1, 1935.
- ⁸ White, J. C., Okelberry, A. M., and Whitelaw, G. P.: Vasomotor Tonus of the Denerve Artery. *Arch. Neurol. and Psychiat.*, **36**, 1251, 1936.
- ⁹ McCloskey, K., Co Tui, F. W., Mulholland, J., and Wright, A. M.: Adrenalin Necrosis After Sympathectomy. *J. Lab. and Clin. Med.*, **22**, 377, 1937.
- ¹⁰ Atlas, L. N.: Etiology of Vasomotor and Nutritional Changes Following Peripheral Nerve Section. *Surgery*, **4**, 718, November, 1938.
- ¹¹ Gask and Ross: Surgery of the Sympathetic Nervous System. Wm. Wood, Baltimore, 1937.
- ¹² Potts, L. W.: The Distribution of Nerves to the Arteries of the Leg. *Anat. Anz.*, **48**, 138, 1914.
- ¹³ Pearl, F. L.: Muscle Splitting Extraperitoneal Ganglionectomy. *Surg., Gynec. and Obst.*, **65**, 107, July, 1937.

NEW INCISION FOR CLOSED SPACE INFECTION (FELON) INVOLVING DISTAL PHALANX OF FINGER

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FELONS are among the most common infections of the distal phalanx. The ordinary conception of the pathogenesis of bone felons is Roux's theory, in which he claims that the lymphatic vessels run perpendicular from the skin to the periosteum, which is lifted off the bone and necrosis of the bone ensues. Against this assumption is the very firm attachment of the periosteum to the bone. Kanavel¹ contends that pressure of the edema or pus in closed space infections shuts off the blood supply to the bone and causes necrosis. The epiphysis receives a separate blood supply and is, therefore, not involved in early cases.

In reviewing the literature on incisions for closed space infections, the three most commonly employed are: (A) The midline; (B) fish-mouth; and (C) lateral hockey-stick. Mason,² in his article on infection of the hand, makes the following comments relative to incisions for felons:

(A) A midline incision for felon does not divide the perpendicular connective tissue fibers which attach the skin to the periosteum; the division of which is the essential feature of the operation for drainage of anterior space infections. (B) A fish-mouth incision, while it provides efficient drainage, is followed by a deep furrowed scar which seriously interferes with the use of the finger-tip for the performance of fine acts. Koch³ has also observed that the fish-mouth incision is unduly long in healing and leaves a painful scar over the finger-tip, and also an anesthetic area distal to the scar, which is annoying to anyone attempting to perform delicate manipulations.

(C) The lateral hockey-stick type of incision fulfills the purpose of adequate drainage and does not leave any disabling scars, but does interfere with tactile sensation.

It is with these facts in mind that a new incision is presented, which has been employed for closed space infections, which appears to eliminate the objectionable features of the other incisions. The five illustrations shown in Plate I demonstrate the procedure.

Operative Procedure.—*First Step:* Under gas-oxygen anesthesia, the nail is detached from the skin, nail-bed and matrix (Plate I, Figs. 1 and 2).

Second Step: An inverted U-shaped incision is made close to the tuft of the bone and part of the shaft of the distal phalanx. The perpendicular fibers are cut close to the bone. The pulp is retracted and the closed space is entered. The abscess is found lying just anterior to the distal phalanx (Plate I, Figs. 3 and 4).

Third Step: The mushroom portion of bone is carefully examined for evi-

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dences of osteomyelitis, and if there are any signs of softening, the tuft is removed (Plate I, Fig. 5).

Fourth Step: The abscess cavity is evacuated and the necrotic tissue in anterior space, if present, is cut away and the cavity packed with iodoform gauze. Wet dressings of boric acid are applied. The patient is instructed

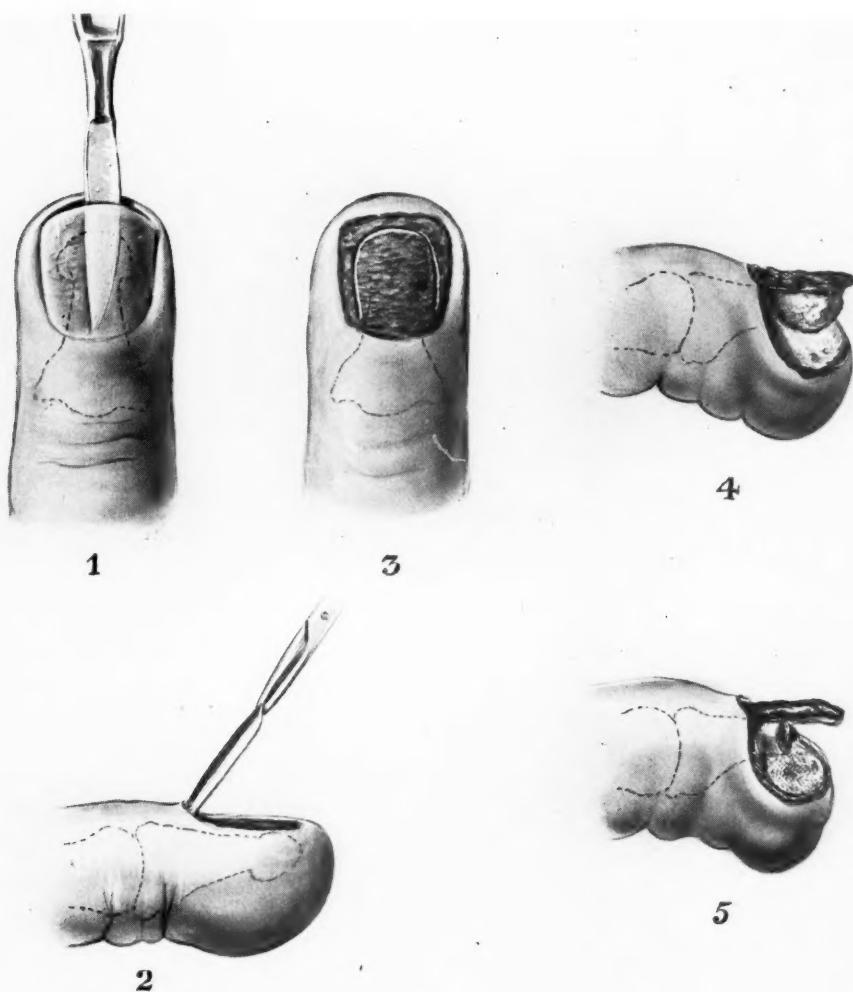


PLATE I.—Figures 1 and 2 show the method employed to detach the nail from its bed, matrix and skin attachments. Figures 3 and 4 show the inverted U-shaped incision carried down close to the tuft and to distal portion of the terminal phalanx. Figure 5 shows the ample exposure obtained, and the resultant gross pathology following removal of the tuft, should it have been found to be involved.

to soak the finger in hot boric acid solution every two hours for 20 minutes. The packing is removed in 48 hours.

The illustrations accompanying the appended case reports show: (1) An early case of closed space infection (2). A case in which the tuft of bone was



FIG. 1.

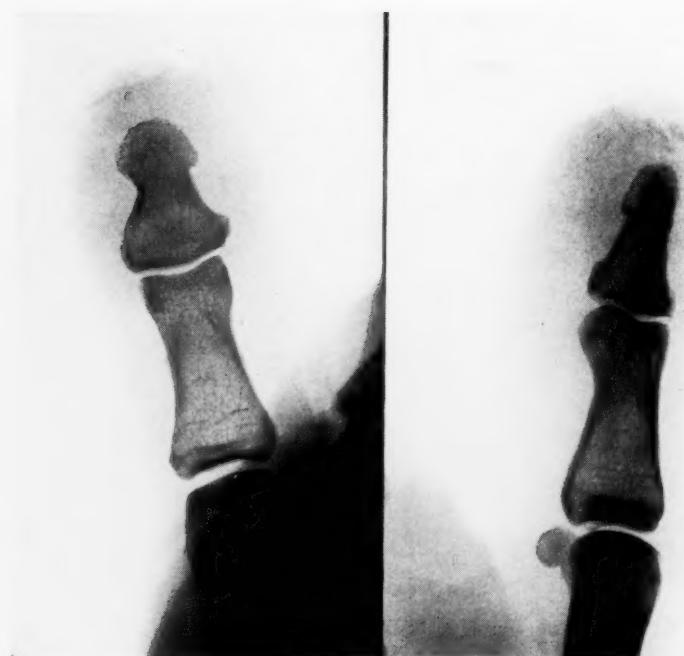


FIG. 2.

FIGS. 1, 2 and 3.—Case 1: Showing, in sequence: (Fig. 1): No evidence of bony involvement. (Fig. 2): One week later, still no evidence of osteomyelitis. (Fig. 3): One month later, still no destruction of the phalanx.



FIG. 3.

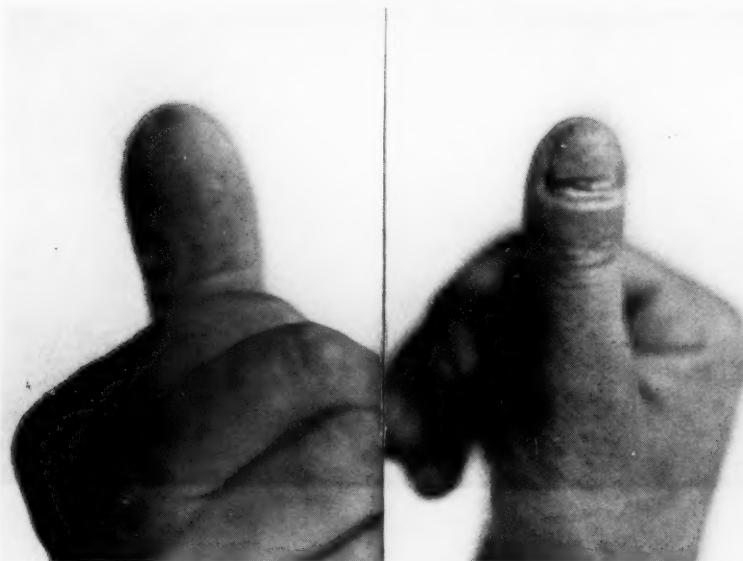


FIG. 4.

FIG. 5.

Figs. 4 and 5.—Case 1: Show the operative wound entirely healed and a new nail regenerating.

involved. (3) An instance where the major portion of the phalanx was destroyed, and in which regeneration has taken place.

CASE REPORTS

Case 1.—A. K., male, white, age 30. On June 29, 1939, a wire penetrated his right thumb. No attention was paid to it until the thumb began to swell and throb. Home



FIG. 6.

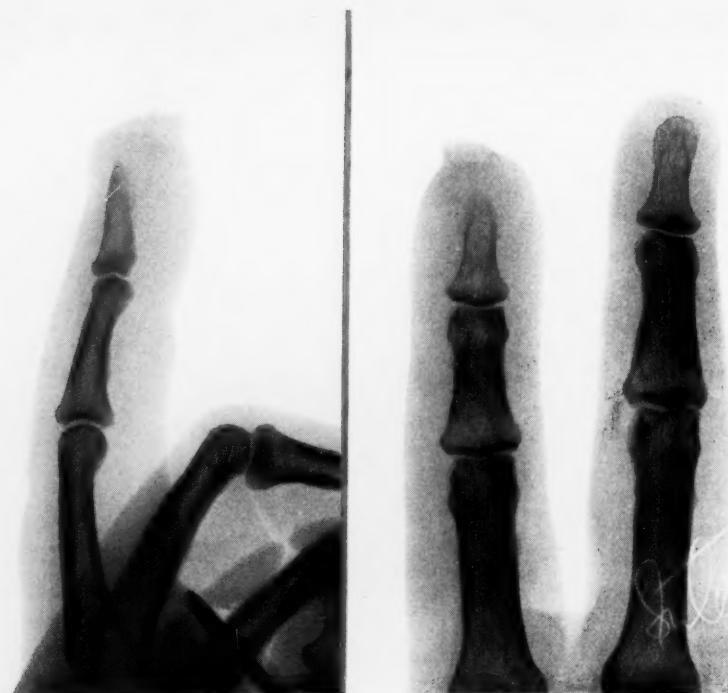


FIG. 7.
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remedies were applied without relief. He was first examined July 7, 1939, one week after the injury. The right thumb was tense, tender and hot, and a small, healed puncture wound was noticed on the volar aspect of the distal portion of the finger. A diagnosis of closed space infection was made. The roentgenogram (Fig. 1) revealed no evidences of bony involvement. Under local infiltration with 1 per cent novocain, the thumb was incised as described in the preceding paragraphs. Roentgenograms taken July 14, 1939 (Fig. 2), and August 14, 1939 (Fig. 3), show no destruction of the phalanx, and photographs taken August 14, 1939 (Figs. 4 and 5), show the wound entirely healed and a new nail regenerating.



FIG. 8.

FIGS. 6, 7, and 8.—Case 2: Showing, in sequence: (Fig. 6) No evidence of bony involvement. (Fig. 7): Ten days later, definite evidences of destruction of the mushroom portion of the distal phalanx. (Fig. 8): Five months later complete regeneration of both bone and nail.

Case 2.—S. S., female, age 28, pricked her left index finger with safety pin March 6, 1939. Very little attention was given it until pain grew very intense. Home remedies were applied without any relief. The condition becoming worse the patient presented herself for examination, March 13, 1939, complaining of pain and swelling of left index finger. The finger was tense, hot, and showed definite evidences of closed space infection. A roentgenogram (Fig. 6) showed no evidences of bony involvement. The finger was opened, employing the previously described incision. A roentgenogram taken March 23, 1939 (Fig. 7), showed definite evidences of destruction of the mushroom portion of the distal phalanx. One taken August 26, 1939 (Fig. 8), shows the bone and nail completely regenerated.

Case 3.—J. T., female, age 42. Presented herself for examination, March 12, 1939, complaining of throbbing pain in right index finger; stating that she had pricked her finger with a needle, a few days previously. The finger was swollen, red, hot, and showed a puncture wound on the volar aspect, which appeared to have a small pustule at the site of entrance. A roentgenogram revealed no evidences of bony involvement (Fig. 9). The finger was opened, employing the previously described incision. A roent-



FIG. 9.

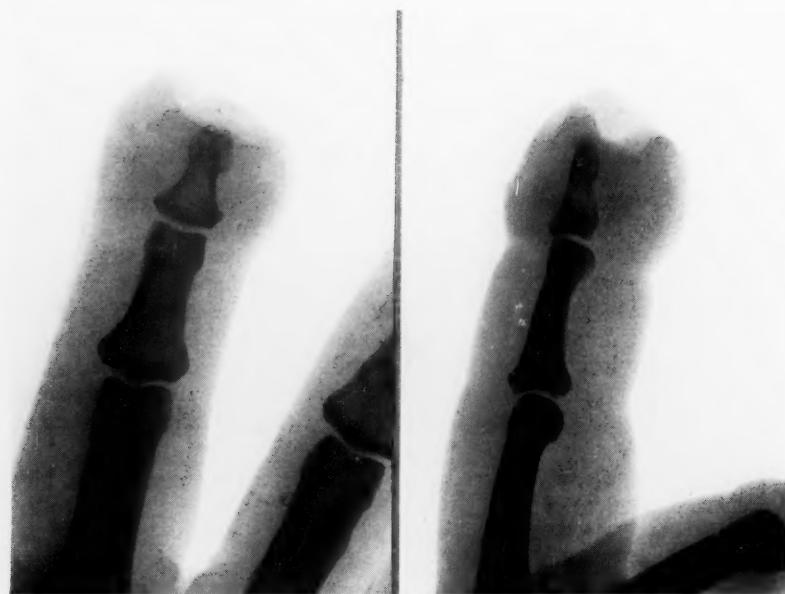


FIG. 10.
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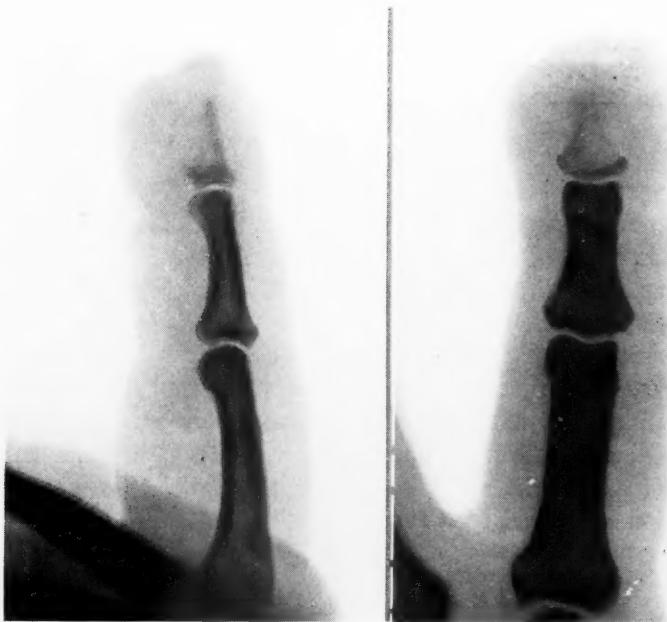


FIG. 11.



FIG. 12.

Figs. 9, 10, 11 and 12.—Case 3: Showing, in sequence: (Fig. 9) No evidence of bony involvement. (Fig. 10): Five days later, still no evidences of osteomyelitis. (Fig. 11): One week later, shows the distal phalanx almost completely destroyed. (Fig. 12): One week later, shows the phalanx regenerating, the wound healing, and regeneration of a new nail.

genogram, taken March 17, 1939 (Fig. 10), still failed to reveal any evidences of osteomyelitis. However, one taken March 24, 1939 (Fig. 11), shows the distal phalanx almost completely destroyed, while another, taken March 31, 1939 (Fig. 12), shows the phalanx regenerating. The distortion of the soft tissues was due to a button-hole abscess; close scrutiny of the film shows wound healing and new nail regenerating.

CONCLUSIONS

The advantages of this incision are:

- (1) The bone is brought closer to the surface and less soft tissue has to be cut through in order to enter the anterior closed space.
- (2) Early osteomyelitis of the bone can be detected long before the roentgenogram reveals evidences of destruction.
- (3) Adequate drainage is obtained and the wound heals in a shorter period of time. If a sequestrum forms, it can be more easily extruded through this incision than through any of those previously recommended.
- (4) There is an absence of scarring on finger, as the nail regenerates completely and covers the scar.
- (5) Sensation is unimpaired.

REFERENCES

- ¹ Kanavel: Hand Infections. Lea & Febiger, Philadelphia, 1939.
- ² Mason: Minn. Med., **20**, 485, August, 1937.
- ³ Koch: Penn. Med. Jour., **40**, 597, May, 1937.

LUXATION OF EXTENSOR TENDONS IN THE HAND

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EXTENSOR TENDONS in the hand may become dislocated following trauma or disease. The resulting condition, although rare, is characteristic. At first glance it resembles, but should not be confused with trigger finger from other causes. The condition of "trigger finger" or "spring finger" is usually described as being due to impediment of the motion of a flexor tendon by narrowing of the tendon sheath or swelling in the course of the tendon. It should be recognized that the same phenomenon, whereby the finger can be flexed voluntarily, but cannot be extended past an apparent obstruction without assistance, may be caused by the lesion which is herewith described.

Legouest,¹ in 1868, described the first case of luxation of an extensor tendon in the hand. After this Paget,² Marsh,³ and Schürmayer⁴ had reported cases before 1900. Recently, Razemon⁵ was able to collect a total of 17 cases due to trauma, in eight of which the reports lacked sufficient detail to offer statistical material. Charcot,⁶ Krukenberg⁷ and Spitz⁸ have reported pathologic luxation from arthritis deformans. Levy⁹ suggested the possibility of a congenital tendency and reported a father and daughter who could voluntarily dislocate an extensor tendon. Other authors have speculated upon the mechanism involved.

After Maydl,¹⁰ the cases can be divided into those due to pathologic softening of structures in the vicinity of the metacarpophalangeal joint, and those due to trauma. The traumatic group may be further divided into those in which the dislocation is caused by a direct blow on the metacarpophalangeal joint which tears the extensor tendon loose from its normal bed, and dislocations from indirect violence caused by contraction of the extensor tendon against resistance; or by external force causing flexion of the finger against muscular resistance. From the recorded cases it appears that the luxation always occurs at the metacarpophalangeal joint. The middle finger was involved in 10 cases; the index finger in three cases. The displacement was toward the ulna in all but one case. Five injuries were caused by direct trauma, of which a fighter's blow to the chin of his opponent may be taken as typical. Five cases, including the present one, were caused by a muscular effort against resistance. One case was apparently due to repeated slight muscular effort. The right and left hands were equally involved.

The patients uniformly give a history of an injury which may be trivial or severe. This is immediately followed by interference with the normal

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function of the finger and swelling on the dorsum of the hand. The swelling and acute pain disappear within a few days, but the extensor function of the finger remains permanently impaired, and there is apt to be pain and weakness on use of the finger.

Examination of the older cases, with the fingers in full extension, reveals an apparently normal hand. As flexion of the fingers is executed, when the proximal phalanx of the finger approaches flexion of 45° , a distinct jerk is observed as the extensor tendon slips off the head of the metacarpal bone. At the same time, the finger jumps into a position of deviation toward the ulnar aspect of the hand. As flexion is continued, the finger can complete full flexion in ulnar deviation. When extension is attempted, the motion

FIG. 1

FIG. 2

FIG. 3



FIG. 1.—Showing the apparent normal relations of the extensor tendon of the middle finger, when in full extension.

FIG. 2.—Showing the extensor tendon of the middle finger beginning to slip to the ulnar side of the third metacarpal, with finger in 45° flexion.

FIG. 3.—Showing ulnar deviation of the middle finger, upon complete flexion, with the extensor tendon slipped entirely to the ulnar side of the third metacarpal.

proceeds normally until the proximal phalanx again reaches the vicinity of a 45° angle, when the motion is locked or impeded. Frequently, it requires assistance from the examiner or the patient's other hand to carry extension past this point; or it may be that by obvious effort, the patient's own extensor muscle may succeed. In any event, there is a visible and palpable jump as the extensor tendon slips back onto the head of the metacarpal bone. The ulnar deviation of the finger disappears and the extension is normally completed. In recent cases, the displacement of the extensor tendon during this procedure may be masked by swelling. It is easily visible and palpable in older cases. In describing the pathology of the condition, all observers have noted the displacement of the tendon. Becker¹¹ recorded an associated tear of the junctura tendinum uniting the extensor tendon to its radial neighbor. Ritschl¹² recorded a case in which the extensor tendon became split, so that the head of the metacarpal projected through the longitudinal tear in button-hole fashion.

Case Report.—A male, age 56, applied at the Central Free Dispensary, July 22, 1937, with the history that one week previously, while bearing his weight on the dorsum of his partly closed fingers as he leaned upon a table, he felt a distinct "pop" and experienced immediate pain in the vicinity of the metacarpophalangeal joint of the middle finger. Since then, the middle finger had been stiff, flexion was painful and extension more so. He had noted swelling in the dorsum of the hand.

Physical Examination: As flexion was executed, the extensor tendon slipped to the ulnar side of the third metacarpal and pulled the finger into ulnar deviation. Exten-

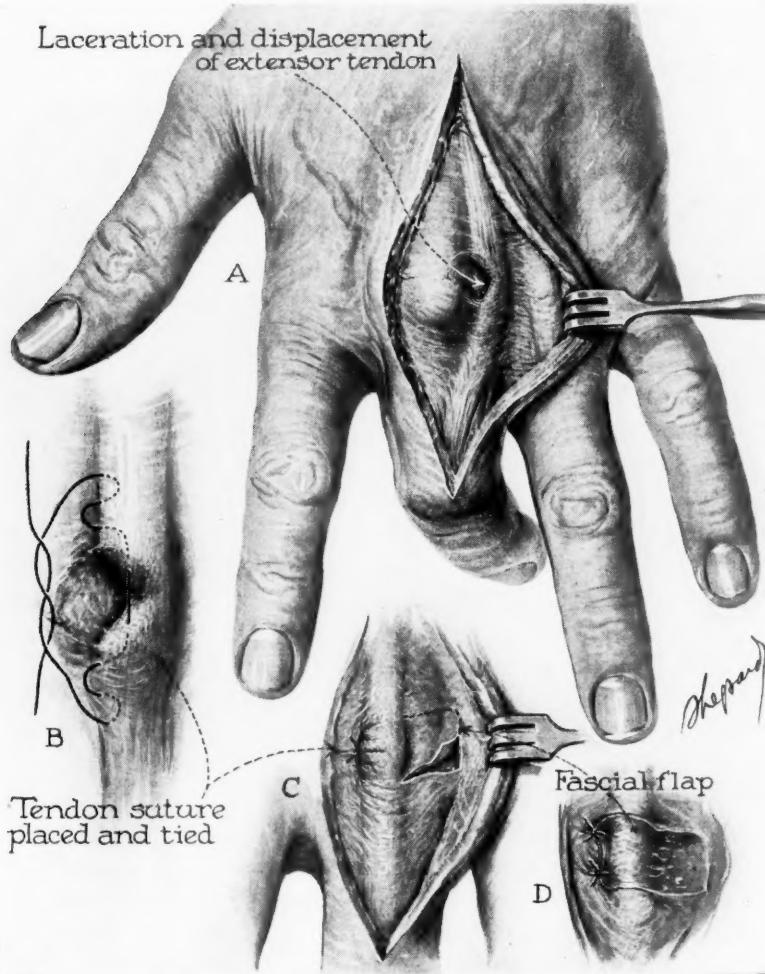


FIG. 4.—Drawing illustrating: (A) The "V" tear in the extensor tendon; an intact vinculum between the extensor tendons of the ring and middle fingers; the absence of vinculum between the extensor tendons of the index and middle fingers. (B) (C) and (D) The operative procedures employed in effecting the repair.

sion occurred to 45°, and then was so impeded that assistance was necessary to spring the extensor tendon back into its normal position, after which extension was completed normally (Figs. 1, 2 and 3). A roentgenogram did not show any bony injury.

Operation.—July 2, 1937: Under local anesthesia, a longitudinal incision was made over the metacarpophalangeal joint of the middle finger and the extensor tendon was exposed. At the level of the metacarpophalangeal joint, the medial one-half of the flat

extensor tendon was found to be torn and separated into a "V" (Fig. 4A). This allowed the intact lateral one-half of the tendon to slide toward the ulnar side of the metacarpal head. It is of interest to note that the dissection was carried widely enough laterally to demonstrate an intact vinculum between the extensor tendons of the ring and middle fingers. There was no vinculum between the extensor tendons of the index and middle fingers. No gross tear was reported in the capsule of the joint, although there was some granulation tissue in this region which may have obliterated such a tear.

The "V" shaped defect in the tendon was repaired by silk suture. (Fig. 4B). A rectangular flap of connective tissue was turned up from the ulnar side of the tendon (Fig. 4C) and sutured over the tendon to the soft tissue on the radial side of the tendon (Fig. 4D). The skin was closed over this with interrupted silk sutures and a palmar splint applied. Eleven days later, the wound was healed. Flexion and extension of the middle finger were normal and there was no luxation of the tendon in any position. One year later the condition was unchanged.

In considering the mechanism of the injury, we must consider the factors which hold the extensor tendon constantly in its normal position over the narrow projection of the metacarpal head. Becker¹¹ believed that this was in part accomplished by the *junctura tendinum* and that laceration of the *junctura tendinum* was a causative factor in dislocation. Silfverskiöld¹³ quotes Braus¹⁴ that the *juncturae* are phylogenetic remnants in man of structures which in the apes are broad membranes limiting individual finger motion in the extensor tendons; and which in man are too variable and too obliquely situated to perform any useful stabilizing function. Poirier¹⁵ states that fixation of the extensor tendon in its proper site is maintained by transverse bands of fascia which unite the tendon to the posterior capsule of the joint and which in turn unite with the palmar aponeurosis. Mason¹⁶ quotes both the preceding theories, and suggests shortening a lax *junctura tendinum* as a possible correction. The discussion among the foregoing authors as to whether the laceration of the *junctura tendinum* or of the posterior aspect of the capsule is the etiologic factor, would obviously apply only to those cases in which the injury is due to direct violence. The mechanical situation is such that indirect violence will apply little or no force to either the *junctura tendinum* or dorsal capsule if the tendon remains intact.

Through the courtesy of Dr. Edwin Miller, I investigated this condition on a number of hands of cadavers. The extensor tendon of the middle finger fuses indistinguishably with the capsule of the metacarpophalangeal joint. This union is so firm that no lateral play is allowed the tendon as it crosses the joint. Proximal to the joint, there is considerable lateral mobility of the tendon. The lateral mobility here is not affected by the presence of the *juncturae tendinum*, which quite obviously, from their oblique situation, play little rôle in stabilizing the lateral position of the tendon. With the scalpel, an incision was made through the radial one-half of the extensor tendon, simulating the lesion found in the case reported. The proximal portion of the tendon was fixed in traction, and the tendon made taut by flexing the middle finger. This caused an obvious tendency on the part of the tendon to slip over the head of the metacarpal bone toward the groove between the

third and fourth metacarpals. However, this luxation was restrained by the attachment of the tendon to the dorsal ligament of the joint. The tension on the dorsal ligament of the joint could be increased by flexing the middle finger in ulnar deviation.

An incision was made on the radial side of an extensor tendon and parallel to it for a distance of three-quarters of an inch at the level of the metacarpophalangeal joint. The preceding procedure was repeated, whereupon the tendon slipped into a position of luxation between the third and fourth metacarpal bones. It is apparent that there must be rupture or division of the dorsal capsule of the joint before lateral displacement of the tendon is possible. This quite conceivably might occur through disease processes. It probably cannot occur through force supplied by muscular contraction against resistance. However, if the radial one-half of the tendon is ruptured, which may happen through an obvious mechanism (the application of power to the extensor tendon while the finger is fixed in flexion with some ulnar deviation), then the continuing force will be applied to the dorsal capsule of the joint. This in turn gives way, and the tendon slips into the groove to the ulnar side of the metacarpal head. Repeated experiments upon a number of tendons, both with and without vincula, appeared to show that this mechanism was correctly interpreted. Division of the vinculum toward the ulnar side of the extensor tendon and tightening of the vinculum toward the radial side when it was present did not prevent the occurrence of the dislocation.

Various authors (Curchod,¹⁷ Silfverskiöld,¹⁸ and Mason¹⁶) have recommended that recent cases be treated conservatively by immobilization in extension for three weeks, by which time the torn tissue may repair itself, inasmuch as the tendon occupies its normal position during extension. In the two cases where this has been done (Curchod and Silfverskiöld), the repair has been sufficient to allow use of the finger, but in both cases there was persistence of partial luxation when the finger was flexed. It would appear that although this method of therapy may be used, it cannot be depended upon for complete restoration, but the functional result may be adequate.

The first operative repair was reported by Haberern,¹⁸ who turned a flap of fibrous tissue over the tendon just proximal to the head of the metacarpal joint to form a retentive sheath in a manner similar to that herewith described. Becker's¹¹ effort to retain the tendon in position by suture of the vinculum resulted in success as far as the luxation of the tendon was concerned, but resulted in limitation of motion.

It would appear that operative repair, in which a retention sling is fashioned from the fibrous tissue just proximal to the metacarpal head, gives good functional and anatomic results. This should be combined with suture of the associated lacerations of tendon and capsule as disclosed by operation.

BIBLIOGRAPHY

¹ Legouest, L.: Société Imperial de Chirurgie. *Gaz. d. Hop.*, 181, 1868. (Quoted by P. Razemon in reference listed below.)

² Paget, J.: Clinical Lectures and Essays (French Translation). C. Balliere, p. 150, 1877.

³ Marsh, H.: Displacements and Injuries of Muscles and Tendons. Brit. Med. Jour., London, **2**, 181, 1896.

⁴ Schürmayer, B.: Über einen Fall von Luxation der Strecksehne des Mittelfingers in der Höhe des Metacarpophalangealgelenks. Zentralbl. f. Chir., Leipzig, **24**, 846, 1897.

⁵ Razemon, P.: Traumatic Dislocation of Extensor Tendon of Second Finger. Ann. Anat. et Pathol., **7**, 238, February, 1930; Echo Méd. du Nord, **34**, 213, May 3, 1930.

⁶ Charcot, J. M.: Neue Vorlesungen über die Krankheiten des Nervensystems, insbesondere über Hysterie. Autoris. deutsche Ausgabe von S. Freud. Wien., 1886, Toepplitz and Deuticke.

⁷ Krukenberg, H.: Beugecontractur der Finger in Folge von Deviation der Strecksehnen. Jahrb. d. Hamburgischen Staatskrankanst, 1890, Leipzig, **2**, 232.

⁸ Spitz, H.: Reposition einer Sehnenluxation durch Sehnenbindung. Arch. f. Orthop., **1**, 401, 1903.

⁹ Levy, Wm.: Über die Sehnenluxation der Fingerstrekker. Zentralbl. f. Chir., **48**, 482, 1921.

¹⁰ Maydl, C.: Über subkutane Muskel- und Sehnenzerrißungen. Deutsch. Ztschr. f. Chir., **17**, 308, 1882.

¹¹ Becker, A.: Beitrag zur traumatischen nicht komplizierten Luxation der Extensorsehnen der Finger. München. med. Wehnschr., **1**, 497, 1903.

¹² Ritschl, A.: Über Fingerbeugekontraktur in Folge von traumatischer Strecksehnen-spaltung. München. med. Wehnschr., **54**, 1127, 1907.

¹³ Silfverskiöld, N.: Luxatio Traumatica Subcutanea Tendin. Extens. Dig. III et Luxatio Habitualis Tend. Extens. Dig. IV man. sin. Acta Chir. Scandinav., **64**, 305, November, 1929.

¹⁴ Braus, H.: Anatomie des Menschen, **1**, 361, 431, 1921.

¹⁵ Poirier, P.: Traité d'Anatomie humaine par Poirier et A. Charpy. Masson et Cie, **2**, 1908.

¹⁶ Mason, M. L.: Rupture of Tendons of Hand, with Study of Extensor Tendon Insertions in Fingers. Surg., Gynec., and Obstet., **50**, 611, March, 1930.

¹⁷ Curchod, E.: Traumatische Sehnenluxation eines Fingerstreckers. Bruns Beiträge z. klin. Chir., **102**, 1916.

¹⁸ Haberern, J.: Über Sehnenluxationen. Deutsch. Ztschr. f. Chir., **62**, 191, 1902.

A METHOD FOR CONTINUOUS SPINAL ANESTHESIA*

A PRELIMINARY REPORT

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DURING the past 16 years, in an experience with more than 2,000 spinal anesthesias, two difficulties have been observed: the first one being "its failure to take"—or failure to produce analgesia; and, the second, "its wearing off too soon"—or pain and muscular contraction returning before the operation is completed, which made it necessary to supplement the spinal with ether, nitrous oxide, cyclopropane, evipal, or local anesthesia.

In approximately 200 continuous spinal anesthesias, no instance has occurred in which it "failed to take." A second injection of procaine hydrochloride (novocain, neocaine) was given many times before there was "a take," and on a few occasions it was necessary to give a third injection before analgesia was produced and the operation begun. The concentration used was 100 mg. of novocain per cubic centimeter of spinal fluid.

In every case in this series, the operation has been completed under spinal anesthesia. Analgesia has been maintained as long as four hours, requiring several injections of novocain. Each subsequent injection has been given as the effects of the previous injection of novocain began to wear off. We have observed that it takes less than two minutes (approximately 90 seconds) to obtain complete freedom from pain and muscular relaxation after an intraspinal injection of novocain. The initial injection of novocain has more toxic effects than subsequent injections. These "toxic effects," of the intraspinal injection of novocain, are evidenced by a fall in blood pressure, sweating, tachycardia, nausea and vomiting. These distressing symptoms are prevented or ameliorated, to some extent, by the use of 10 per cent glucose by continuous venoclysis. The head of the patient is level or slightly lowered. The systolic blood pressure has not dropped below 80 Mm. of mercury, and we have not found it necessary to administer adrenalin or ephedrine to support the blood pressure in any instance. The continuous venoclysis of 10 per cent glucose supports the patient during the operation and analgesia, and the blood pressure is often the same at the conclusion of the operation as it was at the beginning.

Surgeons have experienced the difficulties in closing upper abdominal incisions when it was difficult or impossible to get patients relaxed under general anesthesia. They know the ease with which these incisions are closed when the abdominal wall is perfectly relaxed, and the intestines collapsed. Indeed, at times the abdominal closure is more difficult than the operation,

* Read before the Philadelphia Academy of Surgery, December 4, 1939.

especially when abdominal relaxation cannot be obtained. It will be a comfort to surgeons to find that they can complete their difficult, prolonged operations and close the abdominal incisions under perfect muscular relaxation, and with the intestines collapsed. This I have found to be true in all cases in which continuous spinal anesthesia was used.

The operations in which we have found it to be especially useful are: Gastrectomy, colon resections, rectal resections, operations upon the gall-bladder and bile ducts, plastic procedures, celiotomies, and pelvic operations. The results were so satisfactory that we felt a preliminary report was justified. Animal experimentation, laboratory investigation, and further clinical observations are being carried out at the present time.

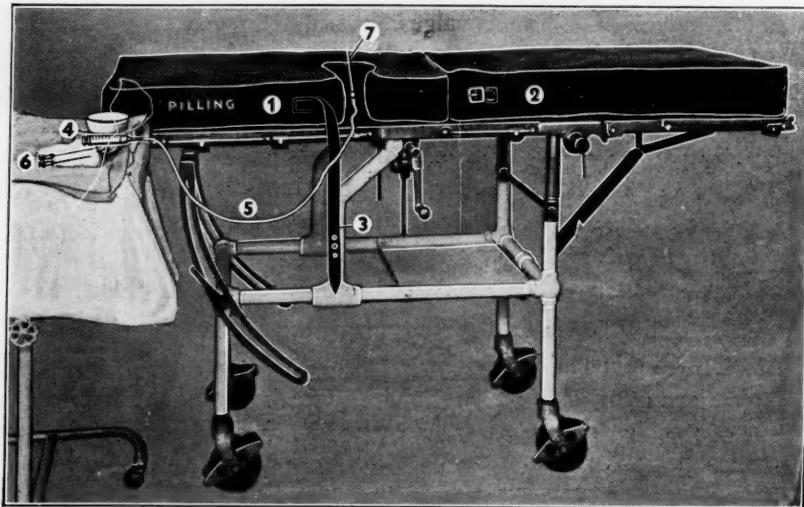


FIG. 1.—Showing the general set-up for the induction of continuous spinal anesthesia.
 (1) The mattress upon which the patient's body rests.
 (2) The part of the mattress that is detached and removed when the patient is in the lithotomy position for perineal or rectal operations.
 (3) The strap that holds the two pads together during abdominal operations.
 (4) A basin, filled with sterile water, containing additional ampules of novocain.
 (5) A very small caliber of rubber tubing, 36 inches long.
 (6) Additional malleable needles of different lengths.
 (7) The malleable needle in place in the position that it usually is when it is left in the patient during operation.

Equipment.—The equipment needed to administer repeated injections into the spinal subarachnoid space, during surgical operations, consists of: (1) A rubber covered pad or mattress. (2) Spinal needles. (3) Rubber tubing. (4) Stopcock. (5) Luer-lok connections. (6) Ten cubic centimeter syringe.

(1) The rubber covered (with zipper) mattress is five inches thick, 18 inches broad and six feet long (Fig. 1). It has a gap seven inches in length that is beneath the lumbar spine when the patient is supine. This gap is continuous with another gap which comes to the side of the mattress. There is a break in the center of this mattress so that the lower part that supports the lower extremities may be detached. This is detached when the patient has the legs in stirrups for plastic or perineal operations. If an abdominal

celiotomy follows the perineal operation, the patient is pulled back in position on the operating table, and the lower half of the rubber-covered mattress is held in place by straps with buckles. This mattress will fit any operating table. Future operating tables and pads may be made with a space for the use of continuous spinal anesthesia.

The spinal puncture is made with the patient lying on one side, and the back of the patient is toward the side of mattress with the gap in it. As soon as the cerebrospinal fluid escapes, six cubic centimeters are drawn into a 10 cc. Luer syringe. The syringe is disconnected, and the needle in the spine plugged with a trocar to prevent escape of spinal fluid. Six hundred milligrams of procaine hydrochloride (novocain, neocaine) is now dissolved in 6 cc. of spinal fluid. The 10 cc. syringe, containing 600 mg. of novocain dissolved in 6 cc. of spinal fluid, is now connected to a Luer-lok connection with a stopcock which connects to about three feet of rubber tubing. This stopcock is opened and 2 cc. of the fluid containing novocain is forced into the rubber tubing. The stopcock is closed. This fluid displaces the air in the tubing. The Luer-lok connection at the opposite end of the tubing is connected to the needle in the spine. This connection is made secure. The stopcock is opened and 1 to 2 cc. of fluid introduced into the subarachnoid space from the 10 cc. syringe. The stopcock is closed, and the 10 cc. syringe now has the remaining fluid left.

The patient is turned on his back with the needle left in the spine, and the needle is so placed that it is in the center of the gap in the pad. It does not touch the table or the mattress at any time. The patient is then tested for analgesia and relaxation. If analgesia is not present within 10 minutes an additional dose of spinal fluid containing novocain is introduced by turning the stopcock and pressing the plunger of the 10 cc. syringe. If additional novocain is needed it may be dissolved in sterile water 100 mg. to each cubic centimeter and introduced as it is required. The spinal puncture is usually made in the second or the third lumbar interspace. The level of analgesia has been easily controlled by the position of the patient, dilution of the analgesic drug, and the force of injection. Procaine hydrochloride has been employed because it is the least toxic of all drugs used in producing spinal anesthesia. I see no reason why such drugs as nupercaine, pontocaine and metycaine cannot be used with this method, but they are more toxic. These drugs were developed to prolong analgesia so that long operations could be completed before their action "wore off." It has been found that any of the above-named drugs may "fail to take" and it has also been noted that they often "wear-off" before they are supposed to and before operations can be completed.

Some patients require much more intraspinal procaine to produce analgesia than others. There is no set dose of ether for a given case, but it is given under control as needed and the dose varies greatly. The same is true in operating under spinal anesthesia. The dose should be given as needed and under control.

Spinal anesthesia is the choice for so many operative procedures, and the

results are not as satisfactory when it has to be supplemented by other anesthetic agents.

(2) *Needles*.—The needles are malleable (made of German silver) and so made that they may be bent in any direction without breaking. The caliber is No. 17- and 18-gauge. They are $2\frac{1}{2}$, 3, and $3\frac{1}{2}$ inches in length, so as to fit fairly accurately the depth of any lumbar spine.

One cubic centimeter of novocain containing $\frac{3}{4}$ grain ephedrine sulphate is withdrawn from an ampule through a hypodermic needle into a 2 cc. Luer syringe. This is injected intradermally over the second or third lumbar interspace. An ordinary spinal needle or a needle of No. 17- or 18-gauge in caliber is introduced through the wheal made by the intradermal injection of novocain and ephedrine. The malleable spinal needle is then introduced into the puncture hole in the skin and on into the subarachnoid space. (The malleable spinal needles will sometimes bend before they can be forced through the skin, but a previous puncture by another needle eliminates the difficulty.)

We now use malleable spinal needles in the induction of all spinal anesthesias and all spinal punctures on the Surgical Services. Within one month, two of the ordinary nonmalleable needles were broken off in the spine, due to the patients suddenly bending and moving out of position. These broken needles in the spine are quite difficult, at times, to remove, and constitute a really serious accident, especially when the accident can be prevented by using malleable needles in performing all spinal punctures.

(3) *Rubber Tubing*.—The rubber tubing is made of very hard rubber with very little elasticity, so that it will not bulge and allow fluid to accumulate in its lumen. The lumen of the tubing is just as small as could be obtained. With three feet of rubber, it takes 2 cc. of the spinal fluid to fill the lumen and force out the air. This 2 cc. of fluid and the contained drug remains in the tube and must be subtracted from the total dosage. All tube connections must be air and fluid tight.

(4) *Stopcock*.—The stopcock is placed between the Luer-lok connection to the 10 cc. syringe, and the connection to the rubber tubing. When it is turned in the long axis of the tubing, it is open. When it is perpendicular to the long axis of the tubing it is closed.

(5) *Luer-lok Connections*.—There is one Luer-lok connection that fits the malleable needle placed in the spine. The other Luer-lok connection is placed at the stopcock. It is very important that these be kept tight so that there may be no leakage of air or fluid.

Ten Cubic Centimeter Luer Syringe.—A 10 cc. Luer-lok syringe, or any 10 cc. syringe that fits the connection may be used. Usually 6 cc. of spinal fluid are withdrawn and 600 mg. of novocain dissolved in it. Two cubic centimeters are used to fill the lumen of the rubber tubing, and, 1 or 2 cc. are introduced into the subarachnoid space, to produce analgesia. Two cubic centimeters are left in the syringe to be used as needed.

BRIEF COMMUNICATIONS AND CASE REPORTS

RECONSTRUCTION OF COMMON BILE DUCT*

SEVEN-YEAR RESULT

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Case Report.—Hosp. No. 762: J. L., white, female, age 42, married, was admitted to St. Francis Hospital, and was operated upon by another surgeon, January 30, 1931, at which operation the gallbladder and appendix were removed. The patient was seen in consultation by the writer (T. H. R.) two days later, at which time she was nauseated; the abdomen moderately distended; temperature 101° F.; pulse 100; there was a moderate degree of jaundice present; icteric index 55. *Clinical Diagnosis:* Occlusion of common bile duct.

The wound was immediately reopened and the common duct easily identified. The first ligature seen was found to encircle the common bile duct, just above the point of junction with the cystic duct, and had already initiated a local gangrenous process. There was also a ligature around the stump of the cystic duct.

Operative Procedure.—The ligature around the common duct was removed; a longitudinal incision made in the duct, and a T-tube inserted. A cigarette drain was placed down to the foramen of Winslow, and the wound closed in layers with plain catgut; the skin with silk.

Postoperative Course.—The patient made an uneventful recovery. The icteric index was 30 the first day, and 17 on the third day postoperative. Unfortunately, on the twenty-first postoperative day the T-tube slipped out, and bile began draining from the abdominal wound.

The patient insisted upon going home, February 28, 1931, four weeks postoperative. Four days later, March 4, 1931, the patient was readmitted to the hospital, Hosp. No. 1605, stating that the wound had continued to discharge large quantities of bile, and that she was troubled with a good deal of abdominal distress after meals. Her stools were formed and natural in color. After a few days' rest in the hospital she felt better, but on March 16, 1931, there appeared to be slight jaundice; the icteric index was 11. In a few days the jaundice disappeared and she felt well again. On March 31, 1931, she became decidedly jaundiced, icteric index 40, and stools clay colored.

Second Operative Procedure.—The abdomen was reopened, April 4, 1931, by incising through the old scar, and the common duct again examined. A stenosis of about one inch in length was found at the site of the previous choledochostomy opening. The stenosed part of the duct was excised, and an effort made to approximate the two ends of the duct over a T-tube. As about one inch of the duct had had to be removed, accurate apposition of the ends was not feasible; hence, the likelihood of recurrence of the stricture at this site was most probable.

Reports of various operations designed to establish a fistula to later anastomose into the stomach having, heretofore, been unsatisfactory in a large percentage of cases, a different procedure was attempted which consisted of bringing the longer end of the T-tube up along the posterior wall of the stomach just proximal to the pylorus, sewing a piece of the gastrohepatic omentum about the tube so as to fix it to the stomach wall, with the

* Presented before the New York Surgical Society, October 26, 1938. Submitted for publication January 17, 1939.

idea of having a sinus form along the stomach wall which would later open into the stomach. This procedure was accomplished very easily. The abdominal wound was again closed around the tube and a cigarette drain.

Postoperative Course.—The cigarette drain was removed on the third postoperative day. Bile drained from the abdomen around the T-tube for several days, then ceased. In a few days the T-tube was pinched off with a Murphy-drip clamp for several hours a day until finally the patient was taught to unpinch the clamp for a few minutes night and morning, and to keep the tube in position by means of adhesive strips.

The patient was discharged from the hospital, May 2, 1931. She returned every few weeks for examination until October 20, 1931, when she was readmitted, Hosp. No. 4195, for the final operation. She had gained in weight and stated that she felt well and had been doing her usual household duties. Icteric index 10.

Third Operative Procedure.—October 26, 1931: The sinus around the tube was dissected free, down to where the tube had been fastened to the posterior wall of the stomach. A two-inch incision was then made through the anterior wall of the pyloric end of the stomach parallel to its long axis. A stab wound was then made through the posterior wall of the stomach into the sinus containing the tube. Several inches of the longer end of the tube were cut off and the tube pulled through into the stomach. The tube was cut off flush with the inner surface of the posterior wall of the stomach, but was not removed, as it had been retained with so much difficulty and it was thought it would soon be discharged into the stomach. The anterior wall of the stomach was closed transversely to its long axis to avoid narrowing at this point. The excess sinus was cut off and the end sutured. The abdomen was closed without drainage. The patient made an uneventful recovery. On November 12, 1931, a plain roentgenogram of the abdomen showed the tube to be still in position. The patient left the hospital, November 14, 1931, and returned every few months for roentgenologic examination.

On March 9, 1932, this patient was presented before the New York Surgical Society and advice solicited relative to the advisability of removing the tube.

On August 3, 1932, 15 months postoperative, she again returned, Hosp. No. 3352, complaining of a ventral hernia. The herniation which presented consisted of a weakness along the lower end of the scar, and, although the hernia was not disabling, the opportunity was taken advantage of, while effecting its repair, to remove the tube which the roentgenogram showed to be still between the common duct and the stomach.

Fourth Operative Procedure.—August 10, 1932: The old scar was excised under spinocaine anesthesia. The anterior wall of the stomach was opened parallel to its long axis. The tube, which was presenting through the posterior wall of the stomach, was grasped with a hemostat and removed. Bile flowed freely through the new opening. The anterior wall of the stomach was closed transversely to the line of incision as before; the hernia was repaired and the abdomen closed without drainage.

Subsequent Course.—The patient has gained markedly in weight, and has remained well since the last operation, over six years ago, except for an arthritis.

DISCUSSION.—DR. FRANK B. BERRY (New York) recalled the fact that he had shown a similar case before the New York Surgical Society, two years ago, that was still alive, 11 years after the original injury. Here again, a rubber tube was used. The gap in the duct was not as extensive as that confronting Doctor Russell. The rubber tube passed by itself. He wondered why, with the tube functioning so well, Doctor Russell did not leave it alone, to eventually disintegrate and be automatically discharged. Doctor Berry mentioned another case of injury, to which he was not a party, which had been referred to him to have the fistulous tract implanted into the stomach. This was planned in Doctor Berry's case. The secondary operation, however, proved to be extremely simple, because the duct, with its gradual stenosis over

the area, had formed a markedly dilated area and the anastomosis was a much simpler operation than was the case in Doctor Russell's patient.

DR. RUSSELL said that he was advised that if he left the tube alone it would cause trouble and that he had seen several cases of Doctor Erdmann's years before, in which the tube had become filled with gummy material. He felt that it would have continued to function in this case but he also felt that while he had a good opportunity to take it out, he might better take advantage of it.

DR. J. WILLIAM HINTON (New York) recalled that ten years ago it was said that every patient with a duodenal ulcer developed cholecystitis and appendicitis, and so the appendix and gallbladder were taken out. But Doctor Hinton's experience has impressed him that seldom, if ever, does one find any trouble with the gallbladder in such cases, and he himself has never found one really diseased.

DR. JOHN A. MCCREERY (New York) agreed that cholecystitis and appendicitis were relatively infrequent concomitants of ulcer. They should be, according to the old text-books, but this is not the case in patients as they are seen. Occasionally, however, one will find a gallbladder which is involved as a result of adhesions around an old perforation.

HEMANGIOMA OF LIVER*

SUCCESSFUL RESECTION OF LEFT LOBE

JOHN H. MORRIS, M.D.

NEW YORK, N. Y.

Case Report.—Hosp. No. J-5872: M. C., white, female, age 38, reported to the Out-Patient Department, Post-Graduate Hospital, September 29, 1935, complaining of pain in the scar at the site of an incision made 20 years previously for an acute infection of the right index finger. Roentgenologic examination disclosed evidence of bone erosion. Other than the present finger infection she, apparently, had never been ill before. She had had seven normal pregnancies. Examination of the right index finger showed a small, tender cicatrix near the tip, but there was no evidence of acute inflammation.

During the course of a routine physical examination, which in the main was entirely negative, there was found a large, grapefruit-sized tumor in the midepigastrum which, according to the patient, had been present since childhood and had never given rise to any pain, digestive or other symptoms. The tumor was firm, lobulated, painless and quite freely movable. It did not, however, move with respirations and, while it could be easily displaced upwards into the epigastrum and laterally, attempts to displace it into the lower abdomen were unsuccessful, indicating a point of fixation above. *Preoperative Diagnosis.*—This seemed to rest between a cyst or tumor of the pancreas, omentum or mesentery.

Operation.—October 7, 1935: Doctor Morris. Upon opening the abdomen through a right pararectus incision, a large, lobulated, beefy, red, glistening tumor was exposed. It was attached above by a broad pedicle to the under surface of the left lobe of the liver. The dome of the right lobe presented a small elevated angiomatic area the size of a half dollar.

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Using a diathermy knife, the left lobe of the liver was resected wide of the tumor pedicle, hemorrhage being effectively controlled by interlocking, deep mattress sutures combined with cauterization. Two large cigarette drains were inserted to site of the excision and the abdomen closed.

Subsequent Course.—Convalescence was uneventful except for a thick discharge along the drainage tract. On discharge from the hospital, November 6, 1935, there was still present a small fistula which, however, had closed completely when seen one month later.

FIG. 1.



FIG. 2.



FIG. 1.—Photograph of the gross specimen of the resected cavernoma of the liver.
FIG. 2.—Photomicrograph showing the histologic structure at the junction of the vascular tumor with the liver.

Follow-Up.—December 5, 1935: A fist-sized mass was found over the right lobe. It appeared probable that the small angiomatic area noted on the right dome of the liver at the time of operation had taken on active post-operative growth.

Treatment on this mass by roentgenotherapy was begun December 10, 1935, and during the succeeding month, eight treatments of a one-third erythema dose were given. When last seen, September 22, 1938, the wound was firmly healed, no masses were palpable, there was no evidence of recurrence and the patient was symptom free.

Pathologic Examination.—*Gross:* Dr. S. M. Rabson: The specimen (Path. No. 32539-65664) measured 180x160 Mm., and weighed 920 Gm. after being sectioned (Fig. 1). Its color varied from light gray to black through reddish-blue and purple; its surface in some areas suggested spleen and in others lung. Its cut section showed evidences of extremely vascular tissue. Between widely separated interlacing bands of firm, gray tissue

HEMANGIOMA OF LIVER

there was moderately firm tissue, grayish-red in color, formed almost exclusively of pin point to pin-head-sized alveolar spaces.

Microscopic.—Sections taken through the neoplasm and liver tissue at their junction, show the liver tissue to be normal in appearance. The vascular tumor is well demarcated from the adjacent liver tissue by numerous lamellae of connective tissue which are continuous with the rich stroma between the blood vessels of the tumor (Fig. 2). The blood vessels are lined by flattened endothelial cells and in some areas connective tissue cells appear to be directly lining the blood spaces. *Pathologic Diagnosis.*—Cavernous hemangioma of the liver (cavernoma).

Ewing⁹ states that these tumors are of congenital origin, on the basis of small nevi, and that they tend to enlarge steadily over a period of many years. When allowed to progress, they attain very large proportions and successively involve neighboring tissues and organs. Some cellular angioma exhibit certain features of malignancy, and are eventually fatal, chiefly through internal hemorrhage and anemia. Virchow traced the earlier stages of cavernoma to islands of proliferating connective tissue surrounding cellular capillaries, and Ribbert found, on the edges of cavernoma, new vessels which communicated freely with those of the tumor but imperfectly with those of the surrounding tissue. Most authorities agree that these growths are partial neoplasms originating from embryonic disturbances.

In 1921, Dr. Charles H. Peck¹ reported a similar case in a female, age 34. The tumor, successfully removed, weighed 3 pounds 14 ounces, and was believed to be the largest tumor to have been removed in the United States and second only to that reported by Pfannenstiel,⁷ which weighed five pounds. Reviewing the literature, he was able to collect 20 cases which had been operated upon, in 17 of whom the tumor was excised, with 15 recoveries and two deaths. The left lobe was most frequently involved (11 cases) with the right lobe second in frequency (7 cases). He records a case (Mantle⁵) in which the patient died from hemorrhage resulting from an accidental needle puncture of the tumor. In another instance (Freund), the patient died from hemorrhage resulting from the rupture of a large hemangioma of the left lobe, which had been exposed during an exploratory celiotomy. Keen⁸ suggests forming an artificial pedicle by incising the liver on either side of the growth, applying an elastic ligature and then packing the wound wide open. Peck cautions against incision or even needle puncture of the tumor itself.

This case is presented because it is an example of a rare type of primary liver tumor whose classification, method of treatment and prognosis are not definitely established. In this instance, radical excision has secured a three-year cure, but it is noteworthy that activity of a small nodule in the right lobe was apparently controlled by roentgenotherapy, confirming the observations of Dr. Bronson S. Ray¹ in a case of extensive, inoperable hemangioma of the liver which has, apparently, also been completely controlled by roentgenotherapy alone.

REFERENCES

¹ Ray, Bronson S.: Large, Cavernous Hemangioma of the Liver. *ANNALS OF SURGERY*, 109, 373-382, March, 1939.

² Peck, C. H.: *Surg., Gynec., and Obstet.*, **33**, 277, 1921.
³ McCallum, W. G.: *Textbook of Pathology*, Phila., 1920, 2nd ed., p. 965.
⁴ Major and Black: *Am. Jour. Med. Sci.*, **469**, 156, 1918.
⁵ Mantle, A.: *Brit. Med. Jour.*, **1**, 365, 1903.
⁶ Chiari, O.: *Muenchen. med. Wchnschr.*, **56**, 1615, 1909.
⁷ Pfannenstiel: *Allg. med. Centr. Ztg.*, **67**, 177, 1898.
⁸ Keen, W. W.: *Penn. Med. Jour.*, **1**, 193, 1897.
⁹ Ewing, J.: *Neoplastic Diseases*, 3rd ed., W. B. Saunders & Co., Phila., 1928.

DISCUSSION.—DR. CHARLES GORDON HEYD (New York): These tumors are relatively rare. They are seldom observed at operation although, not infrequently, they are found at postmortem—according to Adami they were noted 20 times in 1,400 autopsies. It was, furthermore, significant that this tumor had not caused any symptoms and had been discovered during a casual or routine physical examination. Doctor Heyd could not recall having seen any primary tumors of the liver. One thinks of the liver as predominantly the site of fibrotic or biliary changes and not of primary tumors. There are a number of so-called "cavernous" tumors that one sees not infrequently. It was interesting to note that Doctor Morris had called the case one of cavernous hemangioma or cavernoma, which he had thought was associated with age and capillary ectasia, with primary or secondary atrophy of liver cells, whereas hemangioma are tumors of arterial development, arising from or near the edge of the liver, with the apex fixed within the liver tissue and are, as a rule, capable of resection. Doctor Morris stated that Doctor Ewing was responsible for the term "cavernoma," which appears in his book of neoplasms.

As to the symptoms: From the cases Doctor Morris was able to check from the histologic viewpoint, it is remarkable how little difficulty these patients have had as a result of this tumor. This particular patient had recognized the existence of the tumor but owing to the fact that it never gave her any trouble, pain or other discomfort, she had never given it a second thought. That seems to be true of a great many of the reported hemangioma of the liver.

STRANGULATED MECKEL'S DIVERTICULUM

ROWLAND W. BACHMAN, M.D., AND JOHN W. NOBLE, M.D.

ALLENTEOWN, PA.

IN THE EMBRYONIC LIFE of certain individuals, in which the closure and the obliteration of the vitelline duct before birth are imperfectly effected, a portion, or even the whole, of the intra-embryonic segment of the canal may persist as a pervious tube. Although, in extreme cases of faulty closure a passage may lead from digestive tube to the umbilicus, and later open upon the exterior of the body as a congenital umbilical anus, the retention of the lumen of the vitelline duct is usually much less extensive, being limited to the proximal end of the canal, where it is known as Meckel's diverticulum. The latter is connected with the ileum at a point most frequently about 82 cm. (32 inches) from the ileocecal valve. Such diverticula usually measure from

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5 to 7.5 cm. in length, and possess a lumen similar to that of the intestine with which they communicate.

When these conditions are met with in surgery, without an umbilical opening, they are obscure cases to diagnose and can easily be overlooked. The symptoms are most often those of an acute appendicitis or an intestinal obstruction. The pain, colicky in type, is centered more about the umbilicus, more colicky than in an appendiceal involvement and more severe. The tenderness is typically in the region of the umbilicus rather than in the right iliac fossa. As these diverticula so often contain blood within their lumina, blood in the stools may be a valuable clue. The temperature, pulse, respiration, as well as the blood count is not unlike that found in an acute appendicitis. The age of the patient might have some slight significance as the condition generally occurs in children or early adult life.

Case Report.—A schoolboy, age 12, was admitted to the Allentown Hospital, with the history of having felt no ill symptoms until he had eaten a light meal at noon, when he experienced pains in his lower abdomen, radiating to the right iliac fossa. These pains continued and became progressively worse. They were the real colicky pains, so much so that while he was being examined he would say "oh, here comes another pain." He did not vomit but felt slightly nauseated.

Physical Examination revealed tenderness over the appendiceal region, with some slight muscle protection over the lower abdomen. Temperature 98° F., pulse 88, respirations 20. The blood picture showed Hb. 60%, R.B.C. 3,550,000, W.B.C. 10,700; polys. 70%, lymphs. 26%, monos. 4%. Coagulation time 3 minutes.

Operation.—About six hours after the onset of the first symptoms the patient's abdomen was opened through a Deaver incision, under general anesthesia. On opening the abdomen, a clear watery fluid exuded from the incision. This in itself suggested something more serious than just a mild appendicitis. The appendix was found in its normal position, contained several hard concretions and presented a subacute appearance—not acute enough to explain the presence of the clear, watery fluid present.

The appendix was removed, the incision slightly enlarged and the abdomen explored. Nothing unusual was found in the region of the umbilicus, but springing from above the umbilicus, apparently from the ileum, and running longitudinally the length of the abdomen down into the pelvis, was a long cylindrical tube. This was then visualized. Attached to the ileum was a dark red, almost black, Meckel's diverticulum, 15 cm. in length. The distal tip was attached to the mesentery, close to the vertebrae in the pelvis, by a fibrous band.

The distal end of the fibrous band was severed, thereby, freeing the diverticulum. The base was then ligated, clamped and the distal portion excised. The base was then sutured with two rows of linen sutures, invaginating the stump. The abdomen was closed without drainage. The patient was discharged on the twelfth day after operation.

Pathologic Examination.—*Gross:* The specimen was 15 cm. in length and 1 cm. in diameter at its base, and tapered to a fibrous tip which had been adherent to the mesentery. The strangulation was caused by a twisting of its base. The contents of the diverticulum consisted only of blood.

A résumé of this case would indicate two important points in its diagnosis: (1) The presence of true colicky pains in the midabdomen. (2) An abundance of clear watery fluid in the abdomen following a short, acute history.

REFERENCES

- ¹ Mecray, P. M., Ristine, E. R., and Gunter, J. U.: Abdominal Emergencies Associated with Meckel's Diverticulum: Case Report. *Jour. Med. Soc. New Jersey*, **34**, 384-386, June, 1937.
- ² Collins, D. C.: Acute Abdomen Caused by Meckel's Diverticulum. *Canad. Med. Assn. Jour.*, **37**, 564-565, December, 1937.
- ³ Wolfson, W. L., and Kaufman, B.: Acute Inflammation Meckel's Diverticulum. *ANNALS OF SURGERY*, **89**, 535-540, April, 1929.
- ⁴ Obenour, S. W.: Gangrenous Diverticulum Associated with Suppurative Appendicitis. *Ohio State Med. Jour.*, **34**, 175-176, February, 1938.
- ⁵ Cabot: Case 23391 Gangrene Meckel's Diverticulum. *New England Med. Jour.*, **217**, 559-561, September 30, 1937.
- ⁶ Walkling, A. A.: Volvulus of Right Colon and Meckel's Diverticulum. *Amer. Jour. Surg.*, **36**, 705-707, June, 1937.
- ⁷ Hunter, P. M., and Kehr, E. F.: Acute Appendicitis with Acute Meckel's Diverticulitis. *Calif. and Western Med.*, **44**, 199, March, 1936.
- ⁸ Montgomery, A. H.: Surgical Conditions Associated with Meckel's Diverticulum. *Internat. Clin.*, **1**, 216-225, March, 1935.
- ⁹ Pemberton, J. de J., and Stalker, L. K.: Meckel's Diverticulum; Review of 20 Cases with Report of 2 Cases (One with Obstruction and Other with Bleeding Ulcer). *Surgery*, **3**, 563-567, April, 1938.
- ¹⁰ Miller, P. H., and Wallace, R. H.: Meckel's Diverticulum in Acute Abdominal Emergencies. *ANNALS OF SURGERY*, **98**, 713-721, October, 1933.
- ¹¹ Mixter, C. H.: Meckel's Diverticulum and Its Surgical Significance. *Proc. Inst. Med., Chicago*, **9**, 285-308, April 15, 1933.
- ¹² Neiman, A.: Acute, Strangulated Meckel's Diverticulum by Fibrous Band with Gangrene. Case Report. *Ill. Med. Jour.*, **56**, 466-467, June, 1931.
- ¹³ Doolin, W.: Acute Abdominal Emergencies Due to Presence of Meckel's Diverticulum. *Irish Jour. Med. Sci.*, p. 299-305, July, 1929.
- ¹⁴ Hunter, W. C.: Perforated Gangrenous Meckel's Diverticulum in Newborn Infant: Case Report. *Amer. Jour. Dis. Chil.*, **35**, 438-442, March, 1928.

ABDOMINOPERINEAL RESECTION OF THE RECTUM FOR LYMPHOGRANULOMA*

CASE REPORT

JOHN H. MORRIS, M.D.

NEW YORK, N. Y.

Case Report.—W. P., white, male, age 43, was admitted to the Fourth Surgical Division, Bellevue Hospital, May 5, 1938, complaining of anorexia, distention after meals, and loss of weight dating back to an operation performed two years previously, at another hospital, for stricture of the rectum.

Ten years before this date, he had developed rectal symptoms which, he was told, were due to stricture and, during the ensuing eight years, he had been under more or less constant treatment which included five attempts at dilatation of this stricture. The condition, however, became progressively worse and, two years ago, a loop sigmoidostomy was performed. The patient felt much better for the first few months post-

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operative but subsequently began to experience difficulty in emptying the bowel through the colostomy stoma, even with the aid of catheter irrigation. During the past nine months he has noted marked distention and distress after meals, and for this reason has been compelled to limit himself to one meal a day. During this period his weight dropped from 134 to 116 pounds.

Veneral History.—This records a primary luetic infection 15 years ago, confirmed by positive Wassermann reaction, which after prolonged treatment was pronounced negative. He had had an acute gonorrhreal urethritis 11 years ago.



FIG. 1.—Photograph of gross specimen showing the thickened rectal walls and the occluded lumen.

Physical Examination.—The patient appeared undernourished and pallid. Temperature, pulse and respirations were normal. Wassermann negative. Red blood cells 4,400,000; hemoglobin 65 per cent. Urinalysis negative. The abdomen presented, in its left lower quadrant, a loop colostomy which had been sectioned, leaving a proximal and distal stoma, both of which were almost closed by cicatricial contraction about their orifices. In addition, a muscular defect about the proximal stoma permitted a prolapse of this whole area, which, taken together with the strictured orifice, produced, intermittently, an actual obstruction of the proximal loop.

Rectal examination revealed a complete, annular stricture of the rectum two inches above the anal orifice; the mucosa up to this point appeared grossly intact. There was no general or local lymphadenopathy.

The intradermal skin test with the Frei antigen was repeatedly positive, and this result was further confirmed when graded intravenous doses of Frei antigen gave positive results in terms of typical temperature reactions. *Diagnosis.*—Lymphogranuloma inguinale, with anorectal syndrome.

Operation for removal of rectal pathology by means of abdominoperineal resection was decided upon, this step being justified by the consideration that, since lymphogranuloma inguinale is known to be a progressive lymphatic-borne disease which invades and

destroys contiguous tissues, the indication for removal of all active foci is clear. The strictures about the colostomy stomata were interpreted as an extension of the granulomatous process previously noted via rectal lymphatics into sigmoid loop. Furthermore, the status of the sectioned colostomy precluded the possibility of reestablishing continuity of the intestine, so that the distal sigmoid loop and rectum served merely to harbor a dangerous progressive infective focus.

Operation.—May 5, 1938 (Dr. John H. Morris): A plastic, extraperitoneal resection of the distal three inches of the strictured proximal stoma was performed. The hernia in this region was then repaired and new stoma established. After recovery from this procedure the patient was discharged to the O.P.D., but was again admitted for final operation, August 3, 1938. At this time the distal sigmoid stoma was freed, the sigmoid and rectum mobilized from above, and the operation completed by perineal removal. The postoperative course was uncomplicated. The abdominal wound healed per primam and the perineal wound closed by granulation within six weeks.

Pathologic Examination.—*Gross:* Path. No. 3474-38; Doctor Johannsen: Perianal skin shows no new growth or sinus opening and anal mucosa is well preserved. On sectioning the tumor, it is seen that the rectum describes a tortuous course through the mass. Wall of rectum 1.5 to 2 cm. thick and traversed by radial bands of yellow, fibrous connective tissue. Lumen patent, but occluded by pressure from without. Mucous membrane necrotic. *Microscopic:*—Complete destruction of normal architecture. Few areas show muscle fibers. Section, in main, is made up of dense connective tissue in which cellular reaction is scant. There are, near the lumen, a few areas of lymphocytes fairly well walled-off. *Pathologic Diagnosis.*—Chronic productive inflammation.

Present Status.—Patient still complains of some distention after eating, and general weakness of the abdominal muscles. Bowels moving normally through stoma. Weight, however, still subnormal.

COMMENTS.—This case is presented as an example of a rather severe degree of lymphogranuloma inguinale in which surgical therapy seemed to be the sole indication. The significance of the evidence pointing to the extension of the disease process to involve the sigmoid loop is apparent and definitely places this condition in the surgical field, unless some more effective conservative method is devised.

DISCUSSION.—DR. W. HOWARD BARBER (New York) thought that Doctor Morris had very well described a typical case of lymphogranuloma as it is seen at Bellevue Hospital. The cases, when they come to surgery, are chronic, almost hopeless, badly depleted physically, obstructed, suffering from pain and tenesmus, and having considerable bloody and purulent discharge from the rectum. Apparently, the infection spreads not only through the lymphatics but also through the portal blood; and not only by continuity but through the wall of the colon, giving rise to quite extensive ulcerative colitis in some cases. The paramount surgical indication is drainage and the best means to obtain drainage is by resection. Doctor Barber cited personal records of 26 cases operated upon—one plastic operation, two colostomies, and 23 resections, five of which were sacroperineal, and 18 abdominosacroperineal. Of the resections, four were lost, three being very advanced cases with extensive colitis extending well into the descending colon. From the follow-up on these cases it appears that they increase in weight, feel very much improved, and learn to control the artificial anus. On the whole, one feels quite encouraged to continue this line of attack in instances of lymphogranuloma during the advanced chronic stage with rectal symptoms.

CARCINOMA OF PAROTID GLAND

DR. HENRY F. GRAHAM (Brooklyn, N. Y.) felt that the important factor, in cases of lymphogranuloma, is to avoid extensive operation by early diagnosis, and described a case on his service thought to be a very early one of lymphogranuloma. The patient, a young man, came in with marked rectal tenesmus and sphincteric spasm. Proctoscopy revealed a very red anal canal with the lower two or three inches of the rectum involved and showing plaques of fibrin on the surface. The Frei skin test was positive. The patient was given the Elliott treatment with the rectal bag about 10 times and then was transferred for intravenous antigen treatment. At the time of his discharge from the hospital there was marked improvement in his local condition. A similar case was seen in St. Mary's Hospital some time ago. While there was some tendency to stricture formation, it was found that the best results were obtained with diathermy through a rectal applicator. It would be interesting to try to make an earlier diagnosis, followed by heat treatment in addition to antigens.

DR. FRANK B. BERRY (New York) said that about five years ago he read a paper on this subject before the Surgical Section. He had followed about 25 cases over a period of 10 years. The disease is certainly not always progressive, but has a tendency to stay localized without progressing further up the colon. Some of the cases he described were permanently relieved by simple colostomy.

DR. JOHN H. MORRIS, in closing, said that the important factor, of course, is whether or not operation is justified. Many of these cases can be cleared up by conservative methods but in the case reported it seemed utterly futile to waste time, especially in a patient in whom there was quite definite evidence of the progression of the condition into the sigmoid loop. Roentgenotherapy, antigens, *etc.*, would have had little or no effect on this type of pathology and would hardly have been worth instituting.

CARCINOMA OF THE PAROTID GLAND IN A YOUTH

CASE REPORT

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SERVICE OF SECOND SURGICAL DIVISION, ST. VINCENT'S HOSPITAL, NEW YORK, N. Y., DR. R. P. SULLIVAN, DIRECTOR

TUMORS of the parotid gland comprise a group of infrequent and interesting neoplasms. The occurrence of a carcinoma of the parotid in a child, age 11, it was thought, was of sufficient rarity to warrant reporting. The only reference to its appearance at so early an age was by Jambon,⁹ in 1904, who reported a case of epithelioma in the anterior prolongation of the parotid gland in a child, age six. However, in his report the author was unable to state with surety whether the tumor originated from the parotid gland or whether it was an ectodermic cancer which developed secondarily in the parotid gland. The malignant nature of the case herein reported was unsuspected until the pathologic examination was made.

Submitted for publication January 10, 1939.

Case Report.—Hosp. No. 40286: C. L., white, female, age 11, was admitted to St. Vincent's Hospital, August 21, 1938, with the complaint that she had two swellings, one on the right side of her face and the other on the right side of her neck. Whereas the latter had been present on the side of her neck since she was a baby, the former had

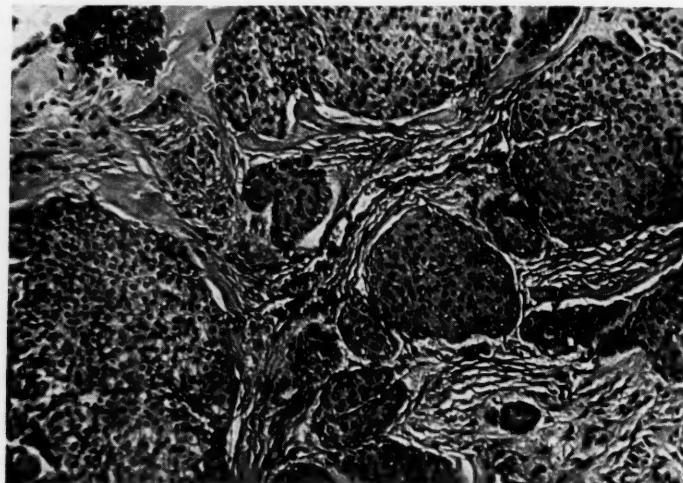


FIG. 1.—The tumor is composed of large polyhedral cells closely massed together into broad columns. (H and E stain; low power.)

become noticeable only about one year ago. This tumor had become slowly but progressively larger during the latter part of the year. Neither of the growths was painful or interfered with mastication. She was observed for six weeks prior to admission to the hospital, during which period there did not appear to be any appreciable change in the size of the growths.

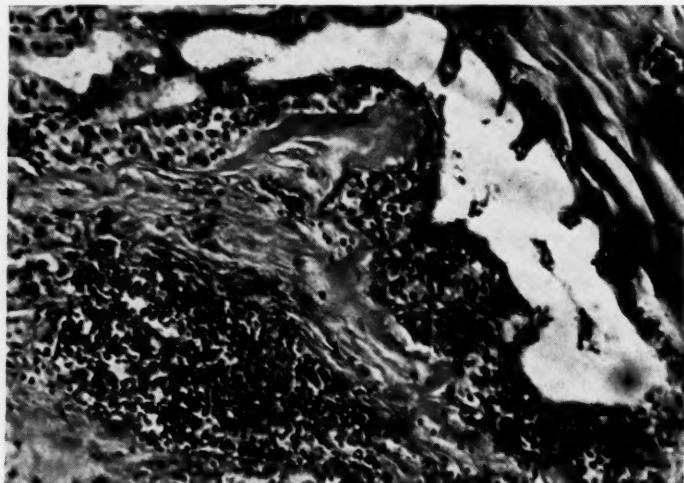


FIG. 2.—A duct within the tumor from the fundus of which a centripetal growth of cells is taking place. (H and E stains; low power.)

Physical Examination revealed a well developed and well nourished child. Her general physical condition was essentially negative.

Local Condition.—TUMOR OF THE RIGHT PAROTID GLAND: A round tumor mass,

CARCINOMA OF PAROTID GLAND

measuring 2.5 cm. in diameter, was intimately attached to the superior portion of the right parotid gland. Externally, it was situated just anterior and somewhat inferior to the tragus of the right ear. The mass appeared to be superficial, was not tender and felt rather firm and smooth on palpation. It could be moved from side to side and in a downward direction but not upward without causing pain. The mass did not appear to be attached to the surrounding tissue except at its most inferior portion. The overlying skin was freely movable and did not appear inflamed. The facial nerve did not appear to be involved.

TUMOR OF THE NECK: The mass in the neck was located just anterior and inferior to the angle of the right mandible and appeared to be attached to the inferior portion of the right submaxillary gland. It was almond-shaped, measuring about 2 cm. in length and 1.5 cm. in width. The growth was situated rather deeply, felt firm, smooth, and was not adherent at any point. There was no pulsation in either of the tumors.

Laboratory Data.—The blood constituents were normal and the blood Kahn was negative. Urine: Negative. Temperature and pulse normal. Roentgenologic examination of the right parotid gland region, May 17, 1938, revealed numerous dense shadows, of varying sizes and shapes. **Roentgenologic Diagnosis:** Calcification of tissues in the region of the right parotid gland.

Operative Pathology.—The inferior margin of the growth in the parotid region was found to be intimately adherent to the superior portion of the parotid gland. The mass in the region of the submaxillary gland was somewhat more deeply situated, and was adherent to the underlying muscles.

Operative Procedure.—An incision was made over the tumor in the parotid, the skin dissected away and the mass exposed. It was dissected away from the surrounding tissue and removed. During the procedure branches of the facial nerve were exposed and retracted. They appeared to lie along the upper border of the mass. The submaxillary mass was excised without difficulty.

Pathologic Examination.—**Gross:** Dr. Antonio Rottino, Path. No. 18174: The specimen consists of three irregular masses, measuring 2x2x2 cm., 1x $\frac{1}{2}$ x $\frac{1}{4}$ cm. and 3x1x1 cm., respectively. The first two consist of dense, chalky, calcified amorphous material, surrounded by a small amount of loose areolar tissue. The third is solid, firm and composed of homogeneous gray tissue subdivided into small lobules by fine, barely visible, septa.

Microscopic: The latter mass is found to be composed of two portions, normal parotid gland and tumor. Between the two is a thin, dense, hyalinized fibrous septum. The tumor is composed principally of broad irregular sheets of large polyhedral cells having distinct cell outlines and clear cytoplasm (Fig. 1). Where the cells are not so closely applied, small intercellular bridges are visible between them. The cell type is uniform throughout. Mitotic figures are not seen. In several portions of the tumor, ducts are found which are identical in appearance to those in the normal portion of the gland. From the fundus of one of these there is a centripetal piling up of cells similar in appearance to those growing elsewhere in sheets (Fig. 2). Tumor growth was found in the lymph channels. **Pathologic Diagnosis:** Primary epidermoid carcinoma of the parotid gland.

Postoperative Course.—Following operation a hematoma developed at the site of excision, causing facial paralysis. Nothing was done about the hematoma because it was felt it would undoubtedly resolve spontaneously without complications. The child's temperature came down to normal on the fourth postoperative day, and she was discharged on the tenth postoperative day, with both wounds well healed.

Subsequent Course.—One month following operation the child began to receive roentgenotherapy at the Memorial Hospital, New York. The progress of her condition appeared to be satisfactory, four months after operation. The facial paralysis had practically completely cleared up and there did not appear to be any recurrence of the tumor.

DISCUSSION.—The clinical diagnosis of parotid tumor is usually easy, but to differentiate benign from malignant growth is rather difficult and often impossible. The most common growths of the salivary glands are mixed tumors, 90 per cent of which are located in the parotid gland according to Neil. These tumors may occur at any age, one having been reported in an infant seven months old. The period of greatest incidence is between the ages of 30 and 60.

In reviewing the literature, primary carcinoma of the parotid gland appears to be an extremely rare condition. Ewing² does not believe that pure malignant epithelial tumors of the salivary glands are rare and maintains that the carcinomata usually develop rapidly and while at first they may be encapsulated, they soon invade the gland, the capsule and regional nodes. However, over a period of 24 years, at the Bernard Free Skin and Cancer Hospital (St. Louis), 65,000 patients were seen and 70 presented themselves with parotid tumors. Fifty per cent of these were malignant. The age of patients with malignant parotid tumors varied from 31 to 84. In the group treated surgically, at the above clinic, microscopic sections showed 14 malignant mixed tumors and three squamous cell carcinomata. A moderate number of investigators agree that there is a certain percentage of the simple mixed tumors which definitely undergo malignant degeneration (25 per cent). Stein and Geschickter¹⁰ made a study of 241 cases of parotid tumors and found only 20 per cent of them to be malignant. They found that the malignant lesions usually occurred in persons over the age of 45, and that they have a fairly rapid rate of growth, with an average duration of four years. On microscopic examination, the tissues revealed adenocystic basal cell features. They maintain that the growths with the basal cell features are more prone to recur after treatment.

PROGNOSIS.—The consensus of opinion is that in carcinoma of the parotid gland the prognosis is very bad. Very few patients have been cured and extensive radical excision with radiation seems to be the only hope. Swinton and Warren¹ recently reported four cases of epidermoid carcinoma, with one death after one and one-half years and two others with no recurrence after two years and the fourth with no recurrence after four years.

The tumor reported in this case was encapsulated and calcified in its upper portion but apparently infiltrating in the lower part. The infiltrating portion, which has been described in the pathologic report, was an epidermoid carcinoma, not very malignant, and one which does not tend to metastasize rapidly. It is hoped that its early excision, followed by radiation, may afford the patient a cure. The prognosis is, however, reserved.

CONCLUSIONS

- (1) A case of primary carcinoma of the parotid gland is herewith reported in a child, age 11.

(2) The early excision of the tumor and intensive radiation may effect a cure; however, the prognosis is reserved.
(3) This case emphasizes the importance of careful pathologic examination of a specimen and possibly the importance of the early removal of any parotid tumor regardless of how innocent it might appear clinically.

REFERENCES

¹ Swinton and Warren: Salivary Gland Tumors. *Surg., Gynec. and Obstet.*, **67**, 4, 1938.
² Ewing, J.: *Neoplastic Diseases*, p. 725. W. B. Saunders Co.
³ Martin, T. M.: Treatment of Tumors of Parotid Gland. *Arch. Surg.*, **36**, 136, 1938.
⁴ Neil, W., Jr.: Observations in 71 Tumors of the Parotid Gland. *Med. Jour. and Rec.*, **136**, 187, 1932.
⁵ McFarland, J.: Tumors of the Parotid Gland. Studies of 135 Cases. *Surg., Gynec. and Obstet.*, **57**, 104, 1933.
⁶ Benedict, E. B., and Meigs, J. V.: Tumors of the Parotid Gland. *Surg., Gynec. and Obstet.*, **51**, 626, 1930.
⁷ Merrit, E. A.: Mixed Tumors of the Parotid Gland. *Amer. Jour. Roentgenol.*, **25**, 507, 1931.
⁸ Jackson, A. S.: Mixed Tumors of the Parotid Gland. *Wisconsin Med. Jour.*, **31**, 606, 1932.
⁹ Jambon: Epithelioma in Parotid Gland in Child. Age Six. *Lyon Med.*, **102**, 257, 1904.
¹⁰ Stein, I., and Geschickter, C.: Tumors of the Parotid. *Arch. Surg.*, **28**, 492, 1934.
¹¹ Lewis, D.: *Practice of Surgery*. Vol. 4. W. F. Prior & Co., Hagerstown, Md.

A COAGULATING SUCKER FOR USE IN NEUROSURGERY

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FOR the last two years we have had in active use an instrument which we find sufficiently helpful to warrant description. It is a combination of suction

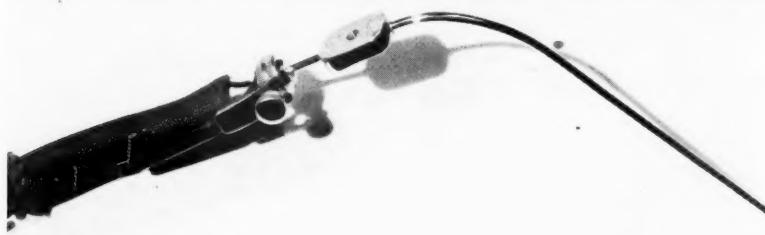


FIG. 1.—The combined metal sucker and electrosurgical attachment as used. The wire and tubing held together by rubber bands.

and electrocoagulation (Fig. 1). The sucker is the metal instrument (Frazier) made by Pilling; a set screw placed near its proximal end provides for the optional attachment of a U-shaped electrode connected with the unit used

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for electrocoagulation, in our case the Burdick instrument (Fig. 2). During use the suction tubing and the wire leading to the coagulating units are held together by two rubber bands. It can thus be as easily handled as the unmodified sucker. Electric current is sent through the metal sucker by pressure on a foot pedal.

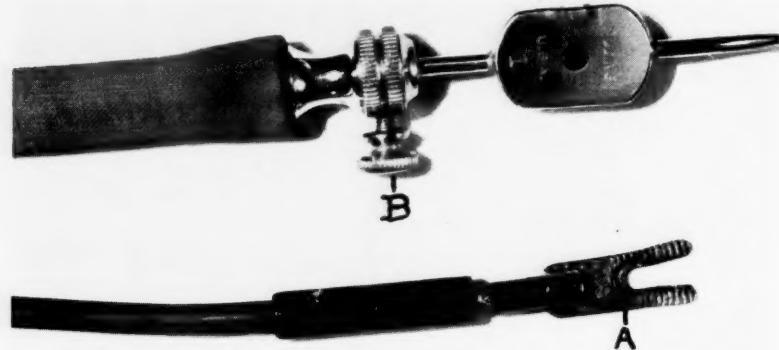


FIG. 2.—Detail of attachment. (A) U-shaped electrode on wire to be attached at set screw (B) on sucker.

The instrument seems particularly helpful in procedures where rapid coagulation in a moderately moist field is desirable. The fact that suction is applied at the moment of coagulation insures maximum efficiency and minimal spread of electrical trauma. Operative technic on the scalp (bone flap) or back muscles and fascia (laminectomy) is much facilitated by its use.

The device was made with the technical assistance of the Hiller and Heuser Company of Boston.

ERRATA

In the article by Drs. Roy D. McClure, F. W. Hartman, J. G. Schnedorf and Victor Schelling: "Anoxia: A Source of Possible Complications in Surgical Anesthesia," ANNALS OF SURGERY, 110, 835-850, November, 1939, on page 835, line 2, the last word should read "necrosis" instead of "narcosis"; and on page 846, line 3 from the bottom, the seventh word should read "for" instead of "from."

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